

MT GL						
		RAOBCOR RICH	RATPAC A UNSW		UAH	
Reanal Avg	1955					
	1956					
	1957					
-0.286	1958	-0.165	-0.292	-0.254		
-0.556	1959	-0.228	-0.354	-0.338	-0.138	
-0.630	1960	-0.246	-0.373	-0.356	-0.214	
-0.749	1961	-0.251	-0.390	-0.325	-0.223	
-0.721	1962	-0.433	-0.549	-0.461	-0.331	
-0.630	1963	-0.290	-0.382	-0.336	-0.257	
-0.750	1964	-0.338	-0.438	-0.506	-0.307	
-0.789	1965	-0.608	-0.713	-0.659	-0.402	
-0.487	1966	-0.379	-0.481	-0.409	-0.247	
-0.788	1967	-0.410	-0.495	-0.457	-0.339	
-0.759	1968	-0.553	-0.629	-0.535	-0.434	
-0.237	1969	-0.309	-0.397	-0.293	-0.195	
-0.460	1970	-0.258	-0.309	-0.318	-0.203	
-1.053	1971	-0.645	-0.691	-0.611	-0.415	
-0.503	1972	-0.483	-0.547	-0.444	-0.343	
-0.374	1973	-0.151	-0.235	-0.204	-0.054	
-0.964	1974	-0.550	-0.615	-0.556	-0.340	
-0.961	1975	-0.467	-0.536	-0.490	-0.237	
-0.893	1976	-0.646	-0.748	-0.659	-0.445	
-0.441	1977	-0.227	-0.360	-0.202	-0.095	
-0.466	1978	-0.237	-0.372	-0.305	-0.175	
-0.193	1979	-0.195	-0.293	-0.161	-0.112	-0.213
-0.204	1980	-0.060	-0.156	-0.058	0.022	-0.062
-0.361	1981	-0.155	-0.237	-0.133	-0.070	-0.154
-0.386	1982	-0.238	-0.306	-0.209	-0.092	-0.230
-0.067	1983	-0.097	-0.147	-0.103	0.063	-0.034
-0.598	1984	-0.420	-0.481	-0.389	-0.196	-0.353
-0.655	1985	-0.427	-0.498	-0.388	-0.241	-0.402
-0.456	1986	-0.316	-0.402	-0.335	-0.193	-0.313

0.076	1987	-0.006	-0.090	-0.016	0.092	-0.009
-0.151	1988	-0.031	-0.074	-0.049	0.063	-0.038
-0.545	1989	-0.283	-0.298	-0.311	-0.128	-0.291
-0.154	1990	0.009	0.005	-0.060	0.109	-0.075
-0.131	1991	0.053	0.040	-0.040	0.117	-0.009
-0.252	1992	-0.207	-0.231	-0.269	-0.097	-0.222
-0.234	1993	-0.298	-0.325	-0.368	-0.140	-0.300
-0.202	1994	-0.226	-0.249	-0.231	-0.075	-0.183
-0.064	1995	-0.217	-0.238	-0.217	-0.065	-0.103
-0.238	1996	-0.320	-0.333	-0.331	-0.191	-0.163
-0.075	1997	-0.289	-0.299	-0.275	-0.118	-0.126
0.461	1998	0.235	0.230	0.202	0.367	0.324
-0.472	1999	-0.278	-0.283	-0.293	-0.096	-0.181
-0.383	2000	-0.318	-0.327	-0.315	-0.165	-0.206
-0.188	2001	-0.118	-0.145	-0.107	-0.001	-0.040
0.025	2002	0.010	-0.020	0.045	0.093	0.092
0.089	2003	0.007	-0.019	0.044	0.125	0.046
-0.018	2004	-0.070	-0.081	-0.043	0.034	-0.040
0.157	2005	0.058	0.061	0.110	0.140	0.048
-0.028	2006	-0.017	-0.008	0.035	0.087	-0.046
-0.046	2007	0.006	0.015	0.010	0.171	-0.007
-0.364	2008	-0.269	-0.263	-0.248	-0.084	-0.256
0.039	2009	-0.026	-0.024	-0.021	0.089	-0.041
0.235	2010	0.187	0.194	0.240	0.403	0.207
-0.247	2011	-0.126	-0.114	-0.097	0.085	-0.142
-0.153	2012	-0.061	-0.052	-0.024	0.095	-0.077
0.026	2013	0.106	0.114	0.119	0.249	0.044
0.063	2014	0.105	0.116	0.100	0.256	0.052
0.286	2015	0.245	0.257	0.260	0.403	0.141
0.544	2016	0.511	0.523	0.449		0.357
0.251	2017	0.297	0.317	0.279		0.215
0.087	2018	0.196	0.227	0.181		0.052
0.422	2019	0.382	0.419	0.382		0.263
0.418	2020	0.443	0.498	0.423		0.301
0.099	2021	0.172	0.238	0.209		0.063
-0.016	2022	0.201	0.204	0.217		0.066
0.564	2023	0.423	0.429	0.459		0.334
1.026	2024	0.857	0.864	0.881		0.722
	2025					

0.171		0.146	0.171	0.151	0.092	0.113
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RSS	NOAA	ERA5	JRA3Q	MERRA2	Sonde Ave	Sat Avg	Reanal Avg
		-0.132	-0.202		-0.237		
		-0.215	-0.331		-0.307		
		-0.353	-0.390		-0.325		
		-0.299	-0.393		-0.322		
		-0.438	-0.511		-0.481		
		-0.315	-0.395		-0.336		
		-0.404	-0.443		-0.427		
		-0.608	-0.623		-0.660		
		-0.326	-0.382		-0.423		
		-0.449	-0.513		-0.454		
		-0.529	-0.594		-0.573		
		-0.233	-0.288		-0.333		
		-0.324	-0.391		-0.295		
		-0.614	-0.686		-0.649		
		-0.456	-0.519		-0.491		
		-0.197	-0.300		-0.197		
		-0.600	-0.696		-0.574		
		-0.484	-0.600		-0.497		
		-0.625	-0.739		-0.684		
		-0.197	-0.330		-0.263		
		-0.243	-0.361		-0.304		
-0.317	-0.231	-0.114	-0.175		-0.216	-0.254	-0.144
-0.153	-0.072	-0.058	-0.088	-0.124	-0.091	-0.096	-0.090
-0.245	-0.149	-0.163	-0.190	-0.233	-0.175	-0.183	-0.195
-0.319	-0.235	-0.237	-0.240	-0.331	-0.251	-0.261	-0.269
-0.116	-0.024	-0.063	-0.074	-0.188	-0.116	-0.058	-0.108
-0.445	-0.357	-0.401	-0.397	-0.502	-0.430	-0.385	-0.433
-0.490	-0.386	-0.433	-0.420	-0.558	-0.438	-0.426	-0.471
-0.415	-0.283	-0.308	-0.290	-0.446	-0.351	-0.337	-0.348

-0.115	0.062	-0.013	0.020	-0.153	-0.037	-0.021	-0.049
-0.146	0.028	0.011	0.045	-0.066	-0.051	-0.052	-0.003
-0.405	-0.229	-0.248	-0.225	-0.344	-0.298	-0.308	-0.272
-0.178	-0.009	0.002	-0.005	-0.120	-0.015	-0.087	-0.041
-0.103	0.053	0.054	0.025	-0.072	0.018	-0.020	0.002
-0.291	-0.179	-0.163	-0.199	-0.261	-0.236	-0.231	-0.207
-0.367	-0.266	-0.299	-0.313	-0.381	-0.330	-0.311	-0.331
-0.242	-0.150	-0.223	-0.202	-0.283	-0.236	-0.191	-0.236
-0.169	-0.082	-0.176	-0.156	-0.225	-0.224	-0.118	-0.186
-0.220	-0.160	-0.268	-0.232	-0.309	-0.328	-0.181	-0.270
-0.173	-0.133	-0.239	-0.206	-0.263	-0.287	-0.144	-0.236
0.291	0.312	0.217	0.277	0.202	0.222	0.309	0.232
-0.188	-0.221	-0.288	-0.225	-0.269	-0.284	-0.197	-0.261
-0.204	-0.247	-0.341	-0.276	-0.300	-0.320	-0.219	-0.306
-0.021	-0.072	-0.152	-0.109	-0.079	-0.124	-0.044	-0.113
0.124	0.058	0.027	0.047	0.108	0.012	0.091	0.061
0.079	0.019	-0.015	0.015	0.101	0.011	0.048	0.034
-0.020	-0.070	-0.072	-0.042	0.052	-0.065	-0.043	-0.021
0.070	0.027	0.026	0.074	0.147	0.076	0.048	0.082
-0.023	-0.061	-0.038	-0.021	0.035	0.003	-0.043	-0.008
0.007	-0.019	0.000	-0.019	0.044	0.010	-0.006	0.008
-0.240	-0.263	-0.244	-0.263	-0.196	-0.260	-0.253	-0.235
-0.027	-0.050	-0.024	-0.053	-0.008	-0.024	-0.039	-0.029
0.218	0.196	0.269	0.238	0.223	0.207	0.207	0.243
-0.121	-0.138	-0.113	-0.118	-0.126	-0.112	-0.134	-0.119
-0.053	-0.078	-0.054	-0.052	-0.049	-0.045	-0.069	-0.052
0.067	0.037	0.105	0.086	0.068	0.113	0.049	0.086
0.080	0.058	0.108	0.075	0.085	0.107	0.063	0.089
0.174	0.151	0.202	0.173	0.180	0.254	0.155	0.185
0.387	0.366	0.435	0.396	0.387	0.494	0.370	0.406
0.245	0.223	0.302	0.268	0.262	0.298	0.228	0.278
0.088	0.077	0.152	0.113	0.135	0.201	0.072	0.133
0.296	0.280	0.378	0.325	0.393	0.395	0.280	0.365
0.336	0.331	0.435	0.372	0.400	0.455	0.323	0.402
0.107	0.125	0.209	0.152	0.200	0.206	0.098	0.187
0.105	0.131	0.214	0.204	0.257	0.208	0.101	0.225
0.374	0.408	0.492	0.464	0.555	0.437	0.372	0.504
0.758	0.773	0.908	0.853	0.969	0.867	0.751	0.910

0.152	0.114	0.143	0.134	0.182	0.156	0.126	0.150
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MT Tropics

	RAOB AVC	RAOBCOR	RICH	RATPAC A	UNSW	UAH	RSS	NOAA
1955								
1956								
1957								
1958	-0.262	-0.031	-0.253	-0.025				
1959	-0.289	-0.182	-0.533	-0.348	-0.310			
1960	-0.276	-0.256	-0.424	-0.391	-0.383			
1961	-0.391	-0.386	-0.603	-0.500	-0.366			
1962	-0.436	-0.485	-0.696	-0.481	-0.415			
1963	-0.294	-0.302	-0.477	-0.452	-0.298			
1964	-0.421	-0.337	-0.582	-0.451	-0.367			
1965	-0.700	-0.551	-0.798	-0.693	-0.402			
1966	-0.338	-0.213	-0.460	-0.276	-0.207			
1967	-0.506	-0.429	-0.634	-0.488	-0.400			
1968	-0.576	-0.567	-0.729	-0.527	-0.466			
1969	0.003	-0.058	-0.213	-0.142	-0.120			
1970	0.130	-0.005	-0.030	-0.238	-0.069			
1971	-0.943	-0.978	-1.003	-0.847	-0.472			
1972	-0.451	-0.435	-0.514	-0.429	-0.310			
1973	-0.135	-0.172	-0.297	-0.167	0.025			
1974	-0.729	-0.775	-0.885	-0.713	-0.419			
1975	-0.677	-0.756	-0.870	-0.678	-0.333			
1976	-0.707	-0.720	-0.912	-0.711	-0.368			
1977	-0.260	-0.262	-0.489	-0.285	-0.156			
1978	-0.191	-0.197	-0.396	-0.279	-0.102			
1979	-0.121	-0.189	-0.303	-0.105	-0.090	-0.186	-0.310	-0.161
1980	0.033	-0.082	-0.205	-0.020	0.078	-0.072	-0.189	-0.043
1981	-0.139	-0.243	-0.355	-0.165	-0.119	-0.231	-0.343	-0.183
1982	-0.107	-0.217	-0.304	-0.107	-0.069	-0.207	-0.318	-0.162
1983	0.234	0.098	0.057	0.170	0.249	0.173	0.074	0.240
1984	-0.461	-0.593	-0.637	-0.541	-0.219	-0.485	-0.606	-0.454
1985	-0.405	-0.524	-0.580	-0.493	-0.250	-0.512	-0.626	-0.462
1986	-0.259	-0.322	-0.435	-0.372	-0.202	-0.359	-0.476	-0.285

1987	0.298	0.189	0.088	0.217	0.207	0.205	0.091	0.317
1988	0.004	-0.133	-0.184	-0.078	0.062	-0.094	-0.216	0.002
1989	-0.363	-0.538	-0.547	-0.491	-0.166	-0.491	-0.613	-0.405
1990	0.096	0.002	-0.009	-0.017	0.151	-0.107	-0.214	-0.013
1991	0.131	0.027	-0.015	-0.031	0.100	-0.034	-0.135	0.054
1992	0.006	-0.084	-0.125	-0.164	0.017	-0.167	-0.247	-0.098
1993	-0.076	-0.200	-0.227	-0.247	-0.023	-0.191	-0.265	-0.139
1994	-0.106	-0.225	-0.247	-0.239	-0.097	-0.174	-0.246	-0.128
1995	0.057	-0.079	-0.106	-0.091	0.060	-0.001	-0.067	0.028
1996	-0.184	-0.365	-0.392	-0.398	-0.208	-0.208	-0.271	-0.203
1997	-0.027	-0.157	-0.205	-0.246	-0.064	-0.020	-0.065	-0.024
1998	0.554	0.365	0.337	0.368	0.423	0.541	0.507	0.524
1999	-0.270	-0.484	-0.490	-0.455	-0.258	-0.338	-0.348	-0.407
2000	-0.237	-0.421	-0.426	-0.430	-0.232	-0.306	-0.308	-0.373
2001	-0.043	-0.194	-0.225	-0.196	-0.132	-0.119	-0.104	-0.174
2002	0.123	0.011	-0.029	0.016	0.032	0.030	0.070	-0.002
2003	0.170	0.048	0.009	0.097	0.121	0.074	0.111	0.044
2004	0.098	-0.052	-0.064	0.011	0.038	-0.042	-0.014	-0.073
2005	0.268	0.079	0.102	0.178	0.100	0.087	0.111	0.065
2006	0.192	0.041	0.072	0.072	0.063	-0.029	-0.015	-0.057
2007	0.083	-0.068	-0.041	-0.019	0.083	-0.058	-0.046	-0.069
2008	-0.243	-0.424	-0.409	-0.415	-0.149	-0.369	-0.358	-0.382
2009	0.150	0.046	0.057	-0.002	0.070	-0.005	0.010	-0.015
2010	0.412	0.237	0.250	0.353	0.410	0.243	0.249	0.229
2011	-0.095	-0.276	-0.254	-0.182	0.095	-0.217	-0.211	-0.231
2012	-0.037	-0.175	-0.161	-0.190	-0.002	-0.215	-0.181	-0.208
2013	0.206	0.066	0.082	0.041	0.278	-0.003	0.028	-0.004
2014	0.232	0.113	0.121	0.057	0.279	0.017	0.049	0.023
2015	0.510	0.383	0.390	0.346	0.488	0.266	0.302	0.275
2016	0.675	0.576	0.580	0.562		0.446	0.484	0.465
2017	0.383	0.273	0.297	0.246		0.163	0.204	0.185
2018	0.222	0.106	0.157	0.101		-0.006	0.038	0.020
2019	0.409	0.381	0.437	0.408		0.276	0.322	0.305
2020		0.451	0.523	0.448		0.358	0.395	0.371
2021		0.087	0.179	0.213		0.029	0.075	0.070
2022		0.080	0.055	0.021		-0.062	-0.031	-0.027
2023		0.512	0.554	0.499		0.407	0.447	0.464
2024		0.966	1.008	0.957		0.855	0.895	0.902
2025								

	0.121	0.147	0.178	0.139	0.074	0.113	0.158	0.102
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UW	ERA-I	ERA5	JRA3Q	MERRA2	Sonde Avg	Sat Avg	Reanal Avg
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		-0.055	-0.139		-0.103		
		-0.270	-0.367		-0.354		
		-0.431	-0.516		-0.357		
		-0.441	-0.552		-0.496		
		-0.520	-0.577		-0.554		
		-0.386	-0.448		-0.410		
		-0.475	-0.500		-0.457		
		-0.655	-0.674		-0.681		
		-0.286	-0.347		-0.316		
		-0.569	-0.601		-0.517		
		-0.612	-0.678		-0.608		
		-0.084	-0.121		-0.138		
		-0.329	-0.373		-0.091		
		-0.919	-0.983		-0.943		
		-0.445	-0.480		-0.459		
		-0.209	-0.301		-0.212		
		-0.830	-0.895		-0.791		
		-0.784	-0.872		-0.768		
		-0.694	-0.800		-0.781		
		-0.295	-0.403		-0.345		
		-0.265	-0.353		-0.291		
-0.171	0.082	-0.109	-0.152		-0.199	-0.219	-0.130
-0.045	0.093	-0.074	-0.116	-0.163	-0.102	-0.101	-0.118
-0.191	-0.086	-0.250	-0.272	-0.319	-0.255	-0.252	-0.280
-0.174	-0.081	-0.235	-0.221	-0.315	-0.210	-0.229	-0.257
0.210	0.239	0.130	0.128	-0.024	0.108	0.162	0.078
-0.473	-0.376	-0.580	-0.582	-0.727	-0.590	-0.515	-0.630
-0.469	-0.390	-0.565	-0.550	-0.761	-0.533	-0.533	-0.625
-0.311	-0.228	-0.382	-0.364	-0.596	-0.377	-0.373	-0.447

0.274	0.289	0.189	0.203	-0.014	0.165	0.204	0.126
-0.038	0.044	-0.058	-0.064	-0.138	-0.132	-0.103	-0.086
-0.443	-0.366	-0.452	-0.458	-0.511	-0.525	-0.503	-0.474
-0.040	0.047	-0.005	-0.031	-0.080	-0.008	-0.111	-0.039
0.031	0.080	0.018	-0.029	-0.052	-0.006	-0.038	-0.021
-0.090	-0.099	-0.109	-0.144	-0.105	-0.124	-0.171	-0.119
-0.106	-0.106	-0.172	-0.203	-0.168	-0.225	-0.198	-0.181
-0.087	-0.115	-0.225	-0.222	-0.203	-0.237	-0.183	-0.217
0.106	0.061	-0.045	-0.042	-0.038	-0.092	-0.013	-0.041
-0.097	-0.160	-0.305	-0.301	-0.280	-0.385	-0.227	-0.295
0.106	0.026	-0.109	-0.085	-0.016	-0.202	-0.036	-0.070
0.686	0.529	0.460	0.499	0.536	0.356	0.524	0.498
-0.206	-0.316	-0.435	-0.380	-0.402	-0.477	-0.364	-0.405
-0.161	-0.246	-0.442	-0.373	-0.393	-0.426	-0.329	-0.403
0.041	-0.043	-0.252	-0.196	-0.180	-0.205	-0.132	-0.209
0.217	0.118	-0.062	-0.038	0.012	-0.001	0.033	-0.029
0.248	0.182	-0.003	0.032	0.107	0.051	0.076	0.045
0.137	0.093	-0.095	-0.054	0.038	-0.035	-0.043	-0.037
0.267	0.263	0.039	0.087	0.149	0.119	0.088	0.091
0.139	0.176	-0.025	0.006	0.025	0.062	-0.034	0.002
0.092	0.114	-0.057	-0.077	-0.059	-0.042	-0.058	-0.065
-0.215	-0.197	-0.342	-0.367	-0.357	-0.416	-0.370	-0.355
0.153	0.162	0.017	-0.009	-0.020	0.034	-0.003	-0.004
0.392	0.386	0.317	0.280	0.207	0.280	0.240	0.268
-0.072	-0.064	-0.175	-0.176	-0.239	-0.237	-0.220	-0.196
-0.051	-0.043	-0.213	-0.207	-0.259	-0.175	-0.201	-0.226
0.147	0.185	0.060	0.050	-0.023	0.063	0.007	0.029
0.163	0.213	0.076	0.057	0.010	0.097	0.030	0.048
0.402	0.474	0.345	0.334	0.290	0.373	0.281	0.323
0.604	0.675	0.513	0.486	0.427	0.573	0.465	0.475
0.325	0.467	0.254	0.226	0.175	0.272	0.184	0.218
0.174	0.343	0.085	0.053	0.028	0.121	0.017	0.055
0.466		0.380	0.341	0.357	0.409	0.301	0.360
		0.499	0.456	0.437	0.474	0.375	0.464
		0.190	0.150	0.148	0.160	0.058	0.162
		0.100	0.094	0.090	0.052	-0.040	0.095
		0.580	0.568	0.607	0.522	0.439	0.585
		1.040	0.993	1.067	0.977	0.884	1.033
0.131	0.110	0.148	0.144	0.173	0.155	0.124	0.152

300-200 Tropics

	RAOBCOR	RICH	RATPAC A	ERA-I	ERA5	JRA55	MERRA2
1955							
1956							
1957							
1958	0.208	-0.06917	-0.112				
1959	-0.057	-0.2125	-0.596				
1960	-0.185	-0.25417	-0.509				
1961	-0.530	-0.55917	-0.682				
1962	-0.463	-0.47125	-0.519				
1963	-0.371	-0.38083	-0.632				
1964	-0.603	-0.56208	-0.622				
1965	-0.964	-0.93417	-0.792				
1966	-0.448	-0.42042	-0.216				
1967	-0.773	-0.71958	-0.579				
1968	-0.765	-0.7925	-0.662				
1969	0.042	-0.00167	-0.106				
1970	0.148	0.314583	-0.192				
1971	-1.394	-1.19333	-1.106				
1972	-0.566	-0.5175	-0.392				
1973	-0.118	-0.05	-0.139				
1974	-0.971	-0.81292	-0.846				
1975	-1.013	-0.83583	-0.812				
1976	-0.974	-0.99042	-0.812				
1977	-0.198	-0.28375	-0.149				
1978	-0.146	-0.20125	-0.229				
1979	-0.055	-0.08708	0.081	0.137	0.111		
1980	0.087	0.03	0.121	0.09	0.068		
1981	-0.227	-0.31917	-0.139	-0.207	-0.225		
1982	-0.240	-0.34625	-0.099	-0.32	-0.281		
1983	0.269	0.2275	0.244	0.188	0.268		
1984	-0.715	-0.74667	-0.722	-0.705	-0.709		
1985	-0.595	-0.64	-0.626	-0.727	-0.695		
1986	-0.207	-0.23292	-0.286	-0.376	-0.291		

1987	0.533	0.500417	0.581	0.472	0.545
1988	0.040	0.051667	0.104	0.069	0.122
1989	-0.592	-0.53375	-0.406	-0.547	-0.515
1990	0.092	0.120417	0.218	0.047	0.11
1991	0.170	0.11125	0.164	0.117	0.17
1992	-0.087	-0.15708	-0.146	-0.172	-0.08
1993	-0.099	-0.17458	-0.219	-0.208	-0.111
1994	-0.031	-0.13125	-0.159	-0.15	-0.08
1995	0.125	0.101667	0.028	0.11	0.132
1996	-0.150	-0.17958	-0.406	-0.18	-0.185
1997	0.154	0.057917	-0.059	0.146	0.162
1998	0.906	0.97375	0.741	0.934	0.964
1999	-0.459	-0.34542	-0.486	-0.376	-0.473
2000	-0.323	-0.19958	-0.426	-0.289	-0.495
2001	-0.056	0.037083	-0.106	0.022	-0.222
2002	0.307	0.350417	0.278	0.263	0.197
2003	0.328	0.3775	0.374	0.311	0.242
2004	0.185	0.239167	0.234	0.195	0.126
2005	0.432	0.54375	0.531	0.486	0.374
2006	0.186	0.37	0.278	0.327	0.202
2007	0.065	0.262917	0.188	0.201	0.198
2008	-0.579	-0.37208	-0.512	-0.376	-0.326
2009	0.138	0.319583	0.194	0.234	0.281
2010	0.389	0.555	0.641	0.622	0.669
2011	-0.328	-0.17917	-0.166	-0.111	-0.073
2012	-0.167	-0.01542	-0.119	-0.078	-0.052
2013	0.176	0.329583	0.214	0.289	0.31
2014	0.300	0.43375	0.281	0.352	0.387
2015	0.628	0.73375	0.644	0.707	0.71
2016	0.995	1.095833	1.051	1.057	1.046
2017	0.496	0.605417	0.538	0.447	0.548
2018	0.275	0.4075	0.307667	0.151	0.325
2019	0.752	0.881667	0.837667		

0.151	0.216	0.164	0.171	0.168	#DIV/0!	#DIV/0!
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		300-150 Tropics		
Sonde Ave	Reanalyses	RAOBCORE	RICH	RATPAC A
		1955		
		1956		
		1957		
0.009		1958	0.336875	0.02625
-0.288		1959	0.0715625	-0.13625
-0.316		1960	-0.0813542	-0.2227083
-0.590		1961	-0.4471875	-0.505625
-0.484		1962	-0.37	-0.4173958
-0.461		1963	-0.3263542	-0.3891667
-0.596		1964	-0.5069792	-0.5215625
-0.897		1965	-0.8857292	-0.89625
-0.361		1966	-0.4047917	-0.4096875
-0.691		1967	-0.6953125	-0.6667708
-0.740		1968	-0.7072917	-0.7489583
-0.022		1969	0.01802083	-0.0364583
0.090		1970	0.221875	0.3009375
-1.231		1971	-1.2984375	-1.1929167
-0.492		1972	-0.5988542	-0.6325
-0.102		1973	-0.1235417	-0.1077083
-0.877		1974	-0.8926042	-0.7869792
-0.887		1975	-0.9366667	-0.8064583
-0.926		1976	-0.9136458	-0.9090625
-0.210		1977	-0.2307292	-0.2928125
-0.192		1978	-0.1497917	-0.1957292
-0.020	0.124	1979	-0.0586458	-0.0792708
0.079	0.079	1980	0.048125	0.00645833
-0.228	-0.216	1981	-0.22125	-0.294375
-0.229	-0.3005	1982	-0.2248958	-0.3065625
0.247	0.228	1983	0.26604167	0.23729167
-0.728	-0.707	1984	-0.7134375	-0.731875
-0.620	-0.711	1985	-0.5903125	-0.6447917
-0.242	-0.3335	1986	-0.19625	-0.2384375

0.538	0.5085	1987	0.50739583	0.4578125
0.065	0.0955	1988	0.05302083	0.05666667
-0.511	-0.531	1989	-0.5178125	-0.4369792
0.143	0.0785	1990	0.12770833	0.1978125
0.149	0.1435	1991	0.20104167	0.18885417
-0.130	-0.126	1992	-0.05	-0.0815625
-0.164	-0.1595	1993	-0.0991667	-0.1584375
-0.107	-0.115	1994	-0.0135417	-0.1034375
0.085	0.121	1995	0.13770833	0.08479167
-0.245	-0.1825	1996	-0.1130208	-0.1892708
0.051	0.154	1997	0.19822917	0.06885417
0.874	0.949	1998	0.89947917	0.91385417
-0.430	-0.4245	1999	-0.4115625	-0.3505208
-0.316	-0.392	2000	-0.306875	-0.2221875
-0.041	-0.1	2001	-0.0627083	0.01552083
0.312	0.23	2002	0.25770833	0.3028125
0.360	0.2765	2003	0.24895833	0.30645833
0.220	0.1605	2004	0.13760417	0.20125
0.502	0.43	2005	0.3728125	0.49614583
0.278	0.2645	2006	0.09510417	0.29145833
0.172	0.1995	2007	-0.0069792	0.20552083
-0.488	-0.351	2008	-0.6084375	-0.3832292
0.217	0.2575	2009	0.04802083	0.24947917
0.528	0.6455	2010	0.33083333	0.51229167
-0.224	-0.092	2011	-0.3404167	-0.1714583
-0.101	-0.065	2012	-0.2344792	-0.0519792
0.240	0.2995	2013	0.0928125	0.26677083
0.338	0.3695	2014	0.2065625	0.3653125
0.669	0.7085	2015	0.51354167	0.6459375
1.047	1.0515	2016	0.86322917	0.98875
0.546	0.4975	2017	0.371875	0.5028125
0.330	0.238	2018	0.18583333	0.33020833
0.824		2019	0.61114583	0.751875
		2020		
		2021		
		2022		
		2023		
		2024		
		2025		

0.177	0.170	#DIV/0!	10.000	0.116	0.184	#DIV/0!
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ERA-I	ERA5	JRA55	MERRA2	Sonde Ave	Reanalyses
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0.182

-0.032

-0.152

-0.476

-0.394

-0.358

-0.514

-0.891

-0.407

-0.681

-0.728

-0.009

0.261

-1.246

-0.616

-0.116

-0.840

-0.872

-0.911

-0.262

-0.173

0.015

-0.069

0.015

0.027

0.027

0.027

-0.212

-0.258

-0.212

-0.293

-0.266

-0.293

0.237

0.252

0.237

-0.716

-0.723

-0.716

-0.661

-0.618

-0.661

-0.273

-0.217

-0.273

0.495	0.483	0.495
0.124	0.055	0.124
-0.493	-0.477	-0.493
0.104	0.163	0.104
0.183	0.195	0.183
-0.061	-0.066	-0.061
-0.119	-0.129	-0.119
-0.086	-0.058	-0.086
0.118	0.111	0.118
-0.193	-0.151	-0.193
0.151	0.134	0.151
0.912	0.907	0.912
-0.429	-0.381	-0.429
-0.49	-0.265	-0.49
-0.21	-0.024	-0.21
0.177	0.280	0.177
0.206	0.278	0.206
0.113	0.169	0.113
0.347	0.434	0.347
0.178	0.193	0.178
0.225	0.099	0.225
-0.283	-0.496	-0.283
0.288	0.149	0.288
0.682	0.422	0.682
-0.024	-0.256	-0.024
-0.031	-0.143	-0.031
0.315	0.180	0.315
0.375	0.286	0.375
0.698	0.580	0.698
1	0.926	1
0.514	0.437	0.514
0.312	0.258	0.312
	0.682	

#DIV/0!	0.172	#DIV/0!	#DIV/0!	0.150	0.172	#DIV/0!
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250-100

	RAOBCORE RICH	RATPAC A	ERA-I	ERA5	JRA55	MERRA2
1955						
1956						
1957						
1958	0.614	0.334				
1959	0.432	0.159				
1960	0.111	-0.122				
1961	0.002	-0.137				
1962	-0.087	-0.222				
1963	0.033	-0.129				
1964	-0.010	-0.138				
1965	-0.449	-0.538				
1966	-0.169	-0.261				
1967	-0.319	-0.344				
1968	-0.472	-0.527				
1969	0.050	-0.018				
1970	0.417	0.337				
1971	-0.922	-0.995				
1972	-0.599	-0.768				
1973	-0.024	-0.142				
1974	-0.637	-0.683				
1975	-0.644	-0.660				
1976	-0.639	-0.592				
1977	-0.271	-0.257				
1978	-0.161	-0.164				
1979	-0.083	-0.049		-0.077		
1980	-0.053	-0.055		-0.005		
1981	-0.172	-0.197		-0.082		
1982	-0.029	-0.060		-0.099		
1983	0.391	0.378		0.394		
1984	-0.583	-0.586		-0.541		
1985	-0.511	-0.564		-0.504		
1986	-0.253	-0.291		-0.221		

1987	0.382	0.324			0.359
1988	0.078	0.056			0.187
1989	-0.306	-0.198			-0.365
1990	0.207	0.336			0.131
1991	0.295	0.354			0.262
1992	0.093	0.112			0.052
1993	0.066	0.029			0.021
1994	0.029	-0.046			-0.091
1995	0.150	0.025			0.099
1996	-0.132	-0.267			-0.279
1997	0.202	0.078			0.016
1998	0.802	0.736			0.694
1999	-0.220	-0.261			-0.212
2000	-0.298	-0.299			-0.456
2001	-0.179	-0.134			-0.332
2002	-0.020	0.037			-0.048
2003	0.049	0.115			0.034
2004	-0.029	0.041			-0.048
2005	0.127	0.236			0.139
2006	-0.034	0.126			0.072
2007	-0.152	0.010			0.193
2008	-0.520	-0.368			-0.171
2009	-0.131	-0.002			0.221
2010	0.227	0.345			0.578
2011	-0.221	-0.100			0.106
2012	-0.386	-0.219			-0.107
2013	-0.073	0.100			0.197
2014	-0.033	0.124			0.290
2015	0.279	0.425			0.550
2016	0.432	0.566			0.692
2017	0.111	0.246			0.398
2018	0.000	0.124			0.221
2019	0.338	0.457			
2020					
2021					
2022					
2023					
2024					
2025					

10.000	0.029	0.081	#DIV/0!	#DIV/0!	0.110	#DIV/0!	#DIV/0!
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		RAOBCOF RICH			RATPAC / ERA-I		ERA5	
		TTT						
Sonde Ave	Reanalyses	RAOBCOF RICH			RATPAC / UAH		RSSv4.0	
		1955						
		1956						
		1957						
0.474		1958	0.038	-0.101	0.024			
0.295		1959	-0.200	-0.245	-0.385			
-0.005		1960	-0.276	-0.286	-0.369			
-0.067		1961	-0.482	-0.591	-0.560			
-0.154		1962	-0.466	-0.503	-0.459			
-0.048		1963	-0.391	-0.413	-0.507			
-0.074		1964	-0.536	-0.594	-0.540			
-0.494		1965	-0.788	-0.966	-0.719			
-0.215		1966	-0.398	-0.452	-0.286			
-0.331		1967	-0.605	-0.752	-0.532			
-0.500		1968	-0.629	-0.825	-0.520			
0.016		1969	0.017	-0.034	-0.111			
0.377		1970	0.047	0.283	-0.199			
-0.959		1971	-1.090	-1.225	-0.915			
-0.684		1972	-0.459	-0.550	-0.380			
-0.083		1973	-0.137	-0.082	-0.124			
-0.660		1974	-0.815	-0.845	-0.695			
-0.652		1975	-0.796	-0.868	-0.702			
-0.615		1976	-0.782	-1.022	-0.722			
-0.264		1977	-0.212	-0.316	-0.202			
-0.163		1978	-0.188	-0.233	-0.238			
-0.066	-0.077	1979	-0.093	-0.119	-0.029	-0.104	-0.169	
-0.054	-0.005	1980	0.045	-0.002	0.023	-0.013	-0.075	
-0.184	-0.082	1981	-0.171	-0.351	-0.099	-0.172	-0.232	
-0.044	-0.099	1982	-0.202	-0.378	-0.170	-0.218	-0.281	
0.385	0.394	1983	0.180	0.195	0.200	0.207	0.160	
-0.585	-0.541	1984	-0.507	-0.779	-0.456	-0.408	-0.480	
-0.538	-0.504	1985	-0.453	-0.672	-0.461	-0.475	-0.539	
-0.272	-0.221	1986	-0.231	-0.265	-0.267	-0.252	-0.320	

0.353	0.359		1987	0.328	0.468	0.347	0.348	0.281
0.067	0.187		1988	0.017	0.020	0.048	0.015	-0.060
-0.252	-0.365		1989	-0.452	-0.566	-0.449	-0.464	-0.541
0.271	0.131		1990	0.026	0.088	0.023	-0.062	-0.125
0.325	0.262		1991	0.086	0.079	0.032	0.025	-0.031
0.103	0.052		1992	-0.116	-0.189	-0.132	-0.177	-0.211
0.047	0.021		1993	-0.096	-0.207	-0.132	-0.127	-0.150
-0.008	-0.091		1994	-0.061	-0.163	-0.071	-0.041	-0.062
0.088	0.099		1995	0.099	0.070	0.080	0.125	0.108
-0.199	-0.279		1996	-0.119	-0.212	-0.216	-0.050	-0.065
0.140	0.016		1997	0.040	0.026	-0.086	0.114	0.116
0.769	0.694		1998	0.657	0.942	0.578	0.748	0.757
-0.240	-0.212		1999	-0.334	-0.377	-0.400	-0.297	-0.257
-0.298	-0.456		2000	-0.222	-0.232	-0.306	-0.197	-0.148
-0.157	-0.332		2001	-0.009	0.005	-0.075	-0.002	0.066
0.008	-0.048		2002	0.231	0.318	0.205	0.208	0.302
0.082	0.034		2003	0.257	0.345	0.280	0.245	0.338
0.006	-0.048		2004	0.153	0.207	0.187	0.102	0.185
0.182	0.139		2005	0.357	0.512	0.422	0.303	0.379
0.046	0.072		2006	0.170	0.338	0.223	0.089	0.157
-0.071	0.193		2007	0.114	0.231	0.200	0.115	0.175
-0.444	-0.171		2008	-0.327	-0.404	-0.294	-0.288	-0.224
-0.067	0.221		2009	0.177	0.288	0.222	0.176	0.239
0.286	0.578		2010	0.412	0.523	0.564	0.411	0.465
-0.160	0.106		2011	-0.172	-0.211	-0.036	-0.125	-0.068
-0.303	-0.107		2012	-0.026	-0.047	0.020	-0.043	0.044
0.013	0.197		2013	0.197	0.298	0.222	0.137	0.221
0.046	0.290		2014	0.268	0.402	0.281	0.187	0.269
0.352	0.550		2015	0.517	0.702	0.538	0.407	0.498
0.499	0.692		2016	0.812	1.064	0.866	0.702	0.793
0.178	0.398		2017	0.465	0.573	0.477	0.352	0.438
0.062	0.221		2018	0.275	0.375	0.299	0.169	0.261
0.398			2019	0.624	0.850	0.684	0.511	0.617
			2020					
			2021					
			2022					
			2023					
			2024					
			2025					

0.055	0.110	#DIV/0!	10.000	0.147	0.216	0.160	0.128	0.179
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0.98587 1 0.97852 0.97511 0.93924

JRA55 MERRA2 Sonde Av Reanalyses

NOAA UW ERA5 JRA55 MERRA2 Sonde Av Sat Avg Reanalyses Avg

			-0.092		-0.013		
			-0.395		-0.277		
			-0.424		-0.310		
			-0.598		-0.544		
			-0.558		-0.476		
			-0.509		-0.437		
			-0.670		-0.557		
			-0.718		-0.824		
			-0.388		-0.379		
			-0.672		-0.629		
			-0.590		-0.658		
			-0.052		-0.043		
			-0.231		0.043		
			-0.918		-1.077		
			-0.317		-0.463		
			-0.143		-0.114		
			-0.767		-0.785		
			-0.764		-0.789		
			-0.690		-0.842		
			-0.182		-0.243		
			-0.243		-0.220		
-0.245	-0.204	-0.009	-0.018		-0.080	-0.186	-0.013
-0.171	-0.103	-0.006	0.014	-0.043	0.022	-0.089	-0.011
-0.285	-0.245	-0.180	-0.160	-0.201	-0.207	-0.238	-0.180
-0.338	-0.300	-0.238	-0.212	-0.295	-0.250	-0.291	-0.248
0.102	0.128	0.175	0.146	0.033	0.192	0.144	0.118
-0.556	-0.517	-0.483	-0.445	-0.531	-0.581	-0.499	-0.487
-0.589	-0.542	-0.512	-0.476	-0.612	-0.529	-0.541	-0.534
-0.367	-0.313	-0.255	-0.231	-0.408	-0.254	-0.316	-0.298

0.255	0.308	0.333	0.332	0.169	0.381	0.294	0.278
-0.096	-0.043	0.067	0.017	0.033	0.028	-0.052	0.039
-0.588	-0.529	-0.395	-0.452	-0.407	-0.489	-0.535	-0.418
-0.161	-0.107	0.061	-0.024	-0.014	0.046	-0.116	0.007
-0.067	-0.019	0.091	0.025	0.039	0.066	-0.025	0.051
-0.247	-0.207	-0.097	-0.168	-0.083	-0.146	-0.209	-0.116
-0.185	-0.142	-0.063	-0.122	-0.040	-0.145	-0.146	-0.075
-0.087	-0.051	-0.048	-0.034	0.033	-0.098	-0.056	-0.016
0.095	0.133	0.122	0.091	0.145	0.083	0.116	0.119
-0.089	-0.041	-0.103	-0.106	-0.037	-0.182	-0.058	-0.082
0.100	0.136	0.077	0.076	0.166	-0.007	0.115	0.107
0.765	0.793	0.703	0.711	0.778	0.726	0.761	0.731
-0.281	-0.269	-0.354	-0.319	-0.315	-0.371	-0.275	-0.329
-0.170	-0.156	-0.311	-0.215	-0.210	-0.253	-0.163	-0.245
0.052	0.056	-0.114	-0.030	-0.004	-0.026	0.054	-0.049
0.306	0.295	0.162	0.226	0.260	0.251	0.298	0.216
0.357	0.317	0.209	0.261	0.323	0.294	0.328	0.265
0.246	0.179	0.082	0.130	0.209	0.182	0.182	0.140
0.480	0.376	0.279	0.366	0.419	0.430	0.377	0.355
0.268	0.156	0.121	0.145	0.153	0.243	0.157	0.139
0.280	0.158	0.153	0.114	0.142	0.181	0.167	0.136
-0.116	-0.232	-0.228	-0.283	-0.262	-0.342	-0.228	-0.258
0.339	0.226	0.237	0.194	0.157	0.229	0.233	0.196
0.577	0.451	0.510	0.443	0.360	0.500	0.458	0.438
0.040	-0.086	-0.054	-0.100	-0.159	-0.140	-0.077	-0.104
0.121	0.015	0.000	-0.003	-0.057	-0.018	0.029	-0.020
0.288	0.180	0.231	0.189	0.113	0.239	0.200	0.178
0.324	0.221	0.287	0.249	0.187	0.317	0.245	0.241
0.552	0.437	0.533	0.474	0.405	0.586	0.468	0.470
0.874	0.751	0.817	0.819	0.694	0.914	0.772	0.777
0.522	0.398	0.488	0.438	0.374	0.505	0.418	0.433
0.359	0.232	0.297	0.264	0.215	0.316	0.246	0.258
0.650	0.568	0.659	0.612	0.601	0.719	0.592	0.624

0.226	0.170	0.154	0.147	0.157	0.174	0.174	0.150
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#DIV/0! #DIV/0! 0.99272 0.9854

From: Ross McKittrick <ross.mckitrick@gmail.com>
Sent: Tuesday, May 20, 2025 9:18 PM
To: John Christy
Cc: Judith Curry; Roy W. Spencer; Steve Koonin
Subject: Re: Model-obs comparison in troposphere
Attachments: CMIP6_20200521_Ross.xlsx

It needs to match the formatting of the attached: each model on a separate sheet, columns and rows positioned just so.

On Tue, May 20, 2025 at 9:12 PM John Christy <climateman60@gmail.com> wrote:
Ross

I can reformat if you could send what you need.

John C.

Sent from my iPhone

On May 20, 2025, at 7:37 PM, Ross McKittrick <ross.mckitrick@gmail.com> wrote:

The updated data you sent are formatted very differently from the earlier spreadsheets and would take a lot of coding to get into the program.

On Tue, May 20, 2025 at 8:35 PM John Christy <climateman60@gmail.com> wrote:
Oh, I see through 2018.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 20, 2025, at 7:04 PM, Ross McKittrick <ross.mckitrick@gmail.com> wrote:

Is this better?

<image.png>

Figure 5.4: Observed versus modeled warming trends in the global lower (LT) and mid-troposphere (MT). Adapted from McKittrick and Christy (2020). Blue dots: warming trends ($^{\circ}\text{C}/\text{decade}$ 1979-2018) with 95% confidence interval bars for 3 data products (satellite, radiosondes and reanalysis) and 95% confidence interval bars. Blue dashed line: warming trend average for 3 observed series. Red dots: modeled warming trends in 36 models.

LT Global

	RAOBCOR	RICH17	RATPAC	UAHv6.0	RSSv4.0	Avg Sat	ERA-I	ERA5
1958	-0.400	-0.410	-0.288					
1959	-0.454	-0.466	-0.380					
1960	-0.474	-0.507	-0.392					
1961	-0.388	-0.465	-0.345					
1962	-0.473	-0.557	-0.477					
1963	-0.451	-0.540	-0.460					
1964	-0.600	-0.680	-0.709					
1965	-0.741	-0.820	-0.727					
1966	-0.511	-0.589	-0.498					
1967	-0.488	-0.563	-0.507					
1968	-0.635	-0.726	-0.572					
1969	-0.352	-0.446	-0.361					
1970	-0.324	-0.387	-0.356					
1971	-0.696	-0.747	-0.644					
1972	-0.546	-0.600	-0.470					
1973	-0.240	-0.285	-0.207					
1974	-0.599	-0.621	-0.565					
1975	-0.574	-0.586	-0.519					
1976	-0.753	-0.780	-0.704					
1977	-0.294	-0.335	-0.230					
1978	-0.337	-0.368	-0.323					
1979	-0.226	-0.250	-0.189	-0.209	-0.280	-0.244	-0.030	-0.146
1980	-0.082	-0.114	-0.060	-0.041	-0.128	-0.085	0.020	-0.065
1981	-0.099	-0.124	-0.067	-0.111	-0.143	-0.127	-0.036	-0.084
1982	-0.307	-0.334	-0.295	-0.296	-0.344	-0.320	-0.236	-0.286
1983	-0.094	-0.111	-0.140	-0.041	-0.112	-0.077	-0.028	-0.060
1984	-0.370	-0.389	-0.351	-0.237	-0.375	-0.306	-0.287	-0.321
1985	-0.322	-0.356	-0.310	-0.361	-0.430	-0.396	-0.312	-0.361
1986	-0.238	-0.285	-0.265	-0.219	-0.313	-0.266	-0.213	-0.241

1987	0.020	-0.012	-0.015	0.050	-0.017	0.016	0.047	0.020
1988	0.027	0.022	0.022	0.039	-0.048	-0.005	0.076	0.071
1989	-0.211	-0.196	-0.224	-0.209	-0.251	-0.230	-0.207	-0.150
1990	0.018	0.041	0.009	0.013	-0.075	-0.031	0.041	0.103
1991	0.025	0.037	-0.030	0.021	-0.029	-0.004	0.026	0.079
1992	-0.314	-0.314	-0.293	-0.280	-0.302	-0.291	-0.298	-0.203
1993	-0.214	-0.227	-0.224	-0.202	-0.238	-0.220	-0.267	-0.178
1994	-0.110	-0.139	-0.070	-0.064	-0.102	-0.083	-0.144	-0.088
1995	-0.021	-0.040	0.028	0.070	0.038	0.054	-0.029	0.032
1996	-0.116	-0.135	-0.153	-0.009	-0.062	-0.036	-0.126	-0.080
1997	-0.079	-0.110	-0.100	-0.007	-0.026	-0.016	-0.105	-0.066
1998	0.458	0.458	0.377	0.484	0.440	0.462	0.346	0.371
1999	-0.029	-0.026	-0.075	-0.017	-0.026	-0.021	-0.119	-0.102
2000	-0.073	-0.072	-0.105	-0.020	-0.032	-0.026	-0.094	-0.128
2001	0.096	0.087	0.094	0.115	0.137	0.126	0.096	0.050
2002	0.218	0.208	0.192	0.217	0.247	0.232	0.195	0.193
2003	0.208	0.203	0.244	0.187	0.263	0.225	0.218	0.187
2004	0.137	0.136	0.143	0.080	0.188	0.134	0.131	0.095
2005	0.313	0.327	0.355	0.199	0.323	0.261	0.331	0.247
2006	0.195	0.223	0.283	0.114	0.235	0.175	0.274	0.173
2007	0.246	0.282	0.266	0.160	0.273	0.216	0.235	0.200
2008	-0.062	-0.018	0.021	-0.101	0.065	-0.018	-0.042	-0.043
2009	0.164	0.213	0.228	0.094	0.235	0.165	0.150	0.160
2010	0.374	0.419	0.454	0.331	0.482	0.407	0.375	0.411
2011	0.064	0.108	0.182	0.016	0.155	0.085	0.076	0.109
2012	0.144	0.190	0.238	0.053	0.211	0.132	0.105	0.151
2013	0.274	0.320	0.357	0.137	0.280	0.209	0.217	0.248
2014	0.307	0.352	0.383	0.182	0.334	0.258	0.251	0.287
2015	0.436	0.475	0.524	0.275	0.459	0.367	0.362	0.401
2016	0.745	0.783	0.766	0.526	0.648	0.587	0.636	0.662
2017	0.546	0.585	0.598	0.403	0.529	0.466	0.452	0.536
2018	0.429	0.468	0.466	0.226	0.389	0.307	0.301	0.413
2019	0.649568	0.687508	0.683475	0.441	0.593467	0.517234		0.612485
79-19	0.187	0.208	0.208	0.132	0.208	0.170	0.142	0.168
95-19	0.227	0.258	0.272	0.109	0.202	0.156	0.186	0.225

					LT Tropics		
JRA	MERRA	Sonde Ave	Sat Avg	Reanal Avg	RAOBCOR RICH		
-0.236		-0.366		-0.236	1958	-0.045	-0.138
-0.354		-0.434		-0.354	1959	-0.317	-0.438
-0.406		-0.458		-0.406	1960	-0.380	-0.492
-0.416		-0.399		-0.416	1961	-0.572	-0.673
-0.493		-0.502		-0.493	1962	-0.529	-0.645
-0.465		-0.484		-0.465	1963	-0.469	-0.595
-0.608		-0.663		-0.608	1964	-0.610	-0.725
-0.660		-0.763		-0.660	1965	-0.780	-0.891
-0.427		-0.533		-0.427	1966	-0.424	-0.516
-0.529		-0.520		-0.529	1967	-0.631	-0.716
-0.574		-0.644		-0.574	1968	-0.620	-0.777
-0.260		-0.386		-0.260	1969	-0.036	-0.192
-0.333		-0.356		-0.333	1970	-0.058	-0.101
-0.641		-0.696		-0.641	1971	-1.015	-1.046
-0.415		-0.539		-0.415	1972	-0.420	-0.482
-0.191		-0.244		-0.191	1973	-0.182	-0.254
-0.611		-0.595		-0.611	1974	-0.804	-0.843
-0.534		-0.560		-0.534	1975	-0.765	-0.800
-0.641		-0.746		-0.641	1976	-0.747	-0.832
-0.233		-0.286		-0.233	1977	-0.214	-0.316
-0.290		-0.343		-0.290	1978	-0.231	-0.291
-0.142		-0.222	-0.244	-0.106	1979	-0.118	-0.174
-0.073	-0.051	-0.086	-0.085	-0.042	1980	0.019	-0.042
-0.127	-0.123	-0.097	-0.127	-0.092	1981	-0.150	-0.221
-0.261	-0.315	-0.312	-0.320	-0.275	1982	-0.214	-0.278
-0.050	-0.108	-0.115	-0.077	-0.061	1983	0.109	0.080
-0.351	-0.382	-0.370	-0.306	-0.335	1984	-0.407	-0.416
-0.357	-0.410	-0.329	-0.396	-0.360	1985	-0.396	-0.420
-0.239	-0.315	-0.263	-0.266	-0.252	1986	-0.222	-0.279

RATPAC	UAH	RSS4.0	ERA-I	ERA5	JRA-55	MERRA-2	Sonde Ave	Sat Avg
0.073					-0.153		-0.037	
-0.316					-0.377		-0.357	
-0.316					-0.415		-0.396	
-0.535					-0.573		-0.593	
-0.458					-0.555		-0.544	
-0.403					-0.479		-0.489	
-0.542					-0.628		-0.625	
-0.711					-0.649		-0.794	
-0.299					-0.377		-0.413	
-0.555					-0.618		-0.634	
-0.462					-0.546		-0.620	
-0.093					-0.064		-0.107	
-0.226					-0.260		-0.128	
-0.833					-0.825		-0.965	
-0.397					-0.300		-0.433	
-0.134					-0.167		-0.190	
-0.693					-0.741		-0.780	
-0.710					-0.717		-0.758	
-0.747					-0.650		-0.775	
-0.263					-0.216		-0.264	
-0.249					-0.271		-0.257	
-0.079	-0.229	-0.114	0.135	-0.008	-0.040		-0.124	-0.171
0.014	-0.098	-0.031	0.086	-0.006	-0.011	-0.026	-0.003	-0.065
-0.099	-0.229	-0.199	-0.091	-0.174	-0.157	-0.189	-0.157	-0.214
-0.195	-0.242	-0.225	-0.114	-0.197	-0.165	-0.254	-0.229	-0.234
0.118	0.159	0.135	0.203	0.144	0.148	0.046	0.102	0.147
-0.364	-0.312	-0.386	-0.340	-0.384	-0.371	-0.440	-0.396	-0.349
-0.383	-0.455	-0.507	-0.384	-0.435	-0.424	-0.522	-0.400	-0.481
-0.278	-0.216	-0.284	-0.204	-0.234	-0.231	-0.371	-0.260	-0.250

0.276	0.309	0.248	0.295	0.277	0.270	0.136	0.246	0.279
0.003	-0.003	-0.061	0.031	0.033	-0.008	0.008	-0.013	-0.032
-0.451	-0.424	-0.443	-0.411	-0.334	-0.396	-0.360	-0.435	-0.433
-0.017	-0.061	-0.102	-0.002	0.057	-0.025	-0.012	-0.027	-0.081
-0.011	0.006	-0.017	0.024	0.062	0.004	0.024	0.019	-0.006
-0.108	-0.177	-0.167	-0.169	-0.090	-0.147	-0.061	-0.130	-0.172
-0.123	-0.115	-0.116	-0.120	-0.046	-0.115	-0.040	-0.128	-0.116
-0.068	-0.037	-0.077	-0.103	-0.047	-0.069	0.003	-0.095	-0.057
0.093	0.135	0.076	0.075	0.110	0.059	0.099	0.075	0.105
-0.171	-0.023	-0.079	-0.115	-0.070	-0.114	-0.066	-0.137	-0.051
-0.072	0.109	0.075	0.042	0.076	0.054	0.126	-0.042	0.092
0.504	0.679	0.588	0.515	0.581	0.581	0.640	0.518	0.633
-0.353	-0.254	-0.282	-0.373	-0.319	-0.269	-0.269	-0.323	-0.268
-0.267	-0.150	-0.187	-0.230	-0.253	-0.192	-0.183	-0.215	-0.168
-0.039	0.025	0.002	-0.028	-0.074	-0.017	0.010	-0.006	0.014
0.197	0.209	0.221	0.148	0.155	0.206	0.245	0.220	0.215
0.249	0.239	0.268	0.217	0.203	0.237	0.299	0.246	0.254
0.206	0.099	0.176	0.116	0.079	0.117	0.212	0.176	0.137
0.377	0.278	0.355	0.318	0.246	0.310	0.382	0.372	0.317
0.238	0.085	0.174	0.182	0.098	0.156	0.155	0.215	0.130
0.188	0.108	0.196	0.125	0.103	0.114	0.118	0.181	0.152
-0.191	-0.254	-0.120	-0.199	-0.191	-0.186	-0.191	-0.178	-0.187
0.219	0.159	0.287	0.207	0.209	0.218	0.148	0.257	0.223
0.524	0.352	0.452	0.381	0.415	0.414	0.305	0.476	0.402
-0.015	-0.142	-0.024	-0.090	-0.080	-0.054	-0.140	-0.062	-0.083
0.087	-0.053	0.078	0.003	0.021	0.045	-0.031	0.098	0.013
0.258	0.099	0.247	0.189	0.200	0.208	0.116	0.268	0.173
0.259	0.146	0.290	0.219	0.237	0.249	0.176	0.296	0.218
0.502	0.353	0.529	0.438	0.472	0.464	0.391	0.512	0.441
0.797	0.628	0.771	0.702	0.724	0.723	0.599	0.792	0.700
0.456	0.333	0.460	0.359	0.447	0.344	0.365	0.466	0.396
0.284	0.141	0.293	0.157	0.278	0.180	0.210	0.277	0.217
0.613	0.473	0.650		0.602	0.492	0.562	0.613	0.561

0.160	0.125	0.175	0.105	0.136	0.136	0.145	0.167	0.150
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MT GL						
		RAOBCOR RICH	RATPAC A UNSW		UAH	
Reanal Avg	1955					
	1956					
	1957					
	1958	-0.162	-0.204	-0.116		
	1959	-0.244	-0.279	-0.203	-0.138	
	1960	-0.255	-0.284	-0.218	-0.214	
	1961	-0.254	-0.291	-0.188	-0.223	
	1962	-0.337	-0.391	-0.322	-0.331	
	1963	-0.209	-0.256	-0.196	-0.257	
	1964	-0.285	-0.325	-0.368	-0.307	
	1965	-0.576	-0.621	-0.523	-0.402	
	1966	-0.306	-0.351	-0.272	-0.247	
	1967	-0.347	-0.382	-0.322	-0.339	
	1968	-0.453	-0.501	-0.397	-0.434	
	1969	-0.201	-0.256	-0.158	-0.195	
	1970	-0.134	-0.149	-0.183	-0.203	
	1971	-0.558	-0.563	-0.476	-0.415	
	1972	-0.454	-0.482	-0.310	-0.343	
	1973	-0.092	-0.138	-0.070	-0.054	
	1974	-0.492	-0.497	-0.421	-0.340	
	1975	-0.407	-0.413	-0.354	-0.237	
	1976	-0.629	-0.657	-0.524	-0.445	
	1977	-0.182	-0.233	-0.066	-0.095	
	1978	-0.215	-0.252	-0.168	-0.175	
0.029	1979	-0.119	-0.149	-0.022	-0.112	-0.110
0.011	1980	0.018	-0.025	0.075	0.022	0.040
-0.153	1981	-0.051	-0.093	0.000	-0.070	-0.051
-0.183	1982	-0.142	-0.167	-0.072	-0.092	-0.128
0.135	1983	0.023	0.011	0.033	0.063	0.069
-0.384	1984	-0.322	-0.344	-0.256	-0.196	-0.250
-0.441	1985	-0.324	-0.357	-0.253	-0.241	-0.299
-0.260	1986	-0.213	-0.254	-0.198	-0.193	-0.209

0.244	1987	0.102	0.061	0.123	0.092	0.093
0.016	1988	0.087	0.084	0.086	0.063	0.066
-0.375	1989	-0.170	-0.142	-0.173	-0.128	-0.188
0.004	1990	0.084	0.119	0.075	0.109	0.029
0.028	1991	0.138	0.164	0.096	0.117	0.095
-0.117	1992	-0.123	-0.119	-0.131	-0.097	-0.119
-0.080	1993	-0.205	-0.212	-0.231	-0.140	-0.197
-0.054	1994	-0.090	-0.118	-0.094	-0.075	-0.080
0.086	1995	-0.050	-0.070	-0.082	-0.065	0.000
-0.091	1996	-0.152	-0.178	-0.197	-0.191	-0.060
0.075	1997	-0.108	-0.146	-0.137	-0.118	-0.022
0.579	1998	0.425	0.410	0.338	0.367	0.425
-0.307	1999	-0.073	-0.077	-0.152	-0.096	-0.080
-0.214	2000	-0.144	-0.153	-0.179	-0.165	-0.103
-0.027	2001	0.051	0.023	0.030	-0.001	0.064
0.189	2002	0.191	0.166	0.181	0.093	0.195
0.239	2003	0.156	0.135	0.178	0.125	0.149
0.131	2004	0.102	0.088	0.095	0.034	0.062
0.314	2005	0.229	0.246	0.242	0.140	0.150
0.148	2006	0.121	0.156	0.167	0.087	0.058
0.115	2007	0.141	0.190	0.143	0.171	0.097
-0.192	2008	-0.143	-0.092	-0.112	-0.084	-0.154
0.195	2009	0.077	0.132	0.111	0.089	0.067
0.379	2010	0.337	0.394	0.373	0.403	0.321
-0.091	2011	-0.005	0.049	0.038	0.085	-0.027
0.009	2012	0.075	0.123	0.108	0.095	0.040
0.178	2013	0.243	0.299	0.255	0.249	0.153
0.220	2014	0.217	0.268	0.234	0.256	0.160
0.441	2015	0.359	0.402	0.394	0.403	0.246
0.687	2016	0.606	0.647	0.576		0.455
0.379	2017	0.432	0.463	0.408		0.317
0.206	2018	0.298	0.335	0.288		0.165
0.552						

0.130	#DIV/0!	0.120	0.143	0.112	0.092	0.090
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							MT Tropics
RSS	ERA5	JRA55	MERRA2	Sonde Ave	Sat Avg	Reanal Avg	
							1955
							1956
							1957
		-0.097		-0.161			1958
		-0.205		-0.216			1959
		-0.283		-0.243			1960
		-0.268		-0.239			1961
		-0.387		-0.345			1962
		-0.283		-0.229			1963
		-0.385		-0.321			1964
		-0.540		-0.530			1965
		-0.292		-0.294			1966
		-0.408		-0.347			1967
		-0.465		-0.446			1968
		-0.169		-0.202			1969
		-0.242		-0.167			1970
		-0.521		-0.503			1971
		-0.368		-0.397			1972
		-0.125		-0.089			1973
		-0.523		-0.438			1974
		-0.407		-0.353			1975
		-0.564		-0.564			1976
		-0.167		-0.144			1977
		-0.216		-0.202			1978
-0.172	0.017	-0.093		-0.100	-0.141	-0.038	1979
-0.008	0.078	0.023	-0.004	0.022	0.016	0.032	1980
-0.101	-0.023	-0.074	-0.117	-0.054	-0.076	-0.071	1981
-0.174	-0.093	-0.151	-0.207	-0.118	-0.151	-0.151	1982
0.029	0.081	0.012	-0.038	0.033	0.049	0.018	1983
-0.300	-0.271	-0.299	-0.379	-0.279	-0.275	-0.316	1984
-0.345	-0.327	-0.321	-0.425	-0.294	-0.322	-0.357	1985
-0.270	-0.180	-0.199	-0.304	-0.214	-0.240	-0.228	1986

0.030	0.152	0.079	0.020	0.094	0.062	0.084	1987
-0.001	0.131	0.077	0.068	0.080	0.032	0.092	1988
-0.260	-0.122	-0.177	-0.209	-0.154	-0.224	-0.169	1989
-0.033	0.143	0.057	0.055	0.097	-0.002	0.085	1990
0.042	0.198	0.083	0.048	0.129	0.068	0.110	1991
-0.146	-0.014	-0.127	-0.111	-0.118	-0.133	-0.084	1992
-0.222	-0.147	-0.194	-0.158	-0.197	-0.210	-0.167	1993
-0.097	-0.088	-0.074	-0.066	-0.094	-0.088	-0.076	1994
-0.024	-0.050	-0.008	-0.011	-0.067	-0.012	-0.023	1995
-0.075	-0.148	-0.094	-0.116	-0.179	-0.068	-0.119	1996
-0.029	-0.103	-0.058	-0.037	-0.127	-0.026	-0.066	1997
0.430	0.352	0.395	0.443	0.385	0.428	0.396	1998
-0.044	-0.165	-0.100	-0.107	-0.100	-0.062	-0.124	1999
-0.060	-0.272	-0.126	-0.119	-0.160	-0.081	-0.172	2000
0.124	-0.086	0.033	0.081	0.026	0.094	0.009	2001
0.269	0.148	0.190	0.220	0.158	0.232	0.186	2002
0.226	0.097	0.159	0.245	0.148	0.188	0.167	2003
0.128	0.054	0.090	0.184	0.080	0.095	0.109	2004
0.218	0.124	0.219	0.286	0.214	0.184	0.210	2005
0.125	0.089	0.129	0.176	0.133	0.091	0.131	2006
0.156	0.140	0.129	0.178	0.161	0.127	0.149	2007
-0.090	-0.130	-0.112	-0.071	-0.108	-0.122	-0.104	2008
0.124	0.118	0.094	0.121	0.102	0.095	0.111	2009
0.370	0.395	0.366	0.351	0.377	0.345	0.371	2010
0.030	0.002	0.020	0.005	0.042	0.001	0.009	2011
0.099	0.064	0.084	0.046	0.100	0.070	0.065	2012
0.220	0.228	0.208	0.183	0.262	0.187	0.206	2013
0.234	0.245	0.222	0.222	0.244	0.197	0.230	2014
0.328	0.363	0.328	0.361	0.389	0.287	0.351	2015
0.541	0.589	0.562	0.520	0.610	0.498	0.557	2016
0.400	0.448	0.389	0.398	0.434	0.359	0.412	2017
0.244	0.288	0.234	0.263	0.307	0.204	0.262	2018
							2019
0.135	0.099	0.116	0.140	0.123	0.112	0.116	

RAOB AVC	RAOBCOR	RICH	RATPAC A	UNSW	UAH	RSS	NOAA	UW
-0.262	-0.202	0.093	0.107					
-0.289	-0.220	-0.069	-0.216	-0.310				
-0.276	-0.214	-0.209	-0.259	-0.383				
-0.391	-0.349	-0.332	-0.368	-0.366				
-0.436	-0.387	-0.389	-0.349	-0.415				
-0.294	-0.240	-0.227	-0.320	-0.298				
-0.421	-0.369	-0.356	-0.319	-0.367				
-0.700	-0.653	-0.648	-0.560	-0.402				
-0.338	-0.297	-0.290	-0.143	-0.207				
-0.506	-0.477	-0.456	-0.354	-0.400				
-0.576	-0.518	-0.532	-0.394	-0.466				
0.003	0.059	0.061	-0.010	-0.120				
0.130	0.123	0.113	-0.106	-0.069				
-0.943	-0.951	-0.953	-0.714	-0.472				
-0.451	-0.432	-0.437	-0.296	-0.310				
-0.135	-0.103	-0.111	-0.035	0.025				
-0.729	-0.721	-0.729	-0.580	-0.419				
-0.677	-0.671	-0.684	-0.545	-0.333				
-0.707	-0.673	-0.680	-0.578	-0.368				
-0.260	-0.211	-0.225	-0.152	-0.156				
-0.191	-0.159	-0.148	-0.147	-0.102				
-0.121	-0.097	-0.085	0.028	-0.090	-0.079	-0.155	-0.209	-0.171
0.033	0.068	0.077	0.112	0.078	0.033	-0.034	-0.107	-0.045
-0.139	-0.102	-0.132	-0.033	-0.119	-0.125	-0.187	-0.227	-0.191
-0.107	-0.083	-0.082	0.026	-0.069	-0.100	-0.163	-0.208	-0.174
0.234	0.242	0.245	0.303	0.249	0.278	0.229	0.186	0.210
-0.461	-0.457	-0.473	-0.408	-0.219	-0.378	-0.451	-0.507	-0.473
-0.405	-0.396	-0.394	-0.360	-0.250	-0.406	-0.470	-0.511	-0.469
-0.259	-0.241	-0.247	-0.239	-0.202	-0.251	-0.321	-0.359	-0.311

0.298	0.317	0.303	0.349	0.207	0.313	0.247	0.226	0.274
0.004	0.008	0.013	0.054	0.062	0.012	-0.061	-0.086	-0.038
-0.363	-0.375	-0.374	-0.359	-0.166	-0.383	-0.458	-0.497	-0.443
0.096	0.088	0.087	0.115	0.151	0.002	-0.059	-0.089	-0.040
0.131	0.139	0.141	0.101	0.100	0.072	0.020	-0.012	0.031
0.006	0.029	0.000	-0.031	0.017	-0.061	-0.091	-0.126	-0.090
-0.076	-0.049	-0.057	-0.114	-0.023	-0.083	-0.110	-0.144	-0.106
-0.106	-0.067	-0.086	-0.106	-0.097	-0.067	-0.091	-0.119	-0.087
0.057	0.084	0.088	0.042	0.060	0.106	0.088	0.072	0.106
-0.184	-0.148	-0.146	-0.266	-0.208	-0.102	-0.116	-0.139	-0.097
-0.027	0.027	0.036	-0.113	-0.064	0.090	0.090	0.074	0.106
0.554	0.577	0.575	0.499	0.423	0.644	0.656	0.660	0.686
-0.270	-0.263	-0.265	-0.320	-0.258	-0.231	-0.193	-0.217	-0.206
-0.237	-0.235	-0.230	-0.297	-0.232	-0.198	-0.153	-0.173	-0.161
-0.043	-0.034	-0.033	-0.063	-0.132	-0.011	0.051	0.037	0.041
0.123	0.134	0.138	0.149	0.032	0.137	0.226	0.229	0.217
0.170	0.180	0.180	0.230	0.121	0.179	0.268	0.285	0.248
0.098	0.103	0.109	0.145	0.038	0.065	0.144	0.199	0.137
0.268	0.240	0.241	0.311	0.100	0.190	0.269	0.362	0.267
0.192	0.147	0.159	0.205	0.063	0.077	0.143	0.240	0.139
0.083	0.033	0.049	0.115	0.083	0.047	0.113	0.203	0.092
-0.243	-0.293	-0.293	-0.281	-0.149	-0.262	-0.199	-0.110	-0.215
0.150	0.093	0.101	0.131	0.070	0.103	0.170	0.256	0.153
0.412	0.351	0.359	0.486	0.410	0.348	0.409	0.507	0.392
-0.095	-0.154	-0.142	-0.047	0.095	-0.110	-0.051	0.043	-0.072
-0.037	-0.086	-0.084	-0.057	-0.002	-0.106	-0.020	0.046	-0.051
0.206	0.150	0.168	0.175	0.278	0.102	0.188	0.246	0.147
0.232	0.186	0.198	0.189	0.279	0.123	0.210	0.258	0.163
0.510	0.470	0.475	0.479	0.488	0.375	0.463	0.507	0.402
0.675	0.637	0.656	0.692		0.550	0.645	0.717	0.604
0.383	0.351	0.381	0.370		0.270	0.364	0.439	0.325
0.222	0.181	0.218	0.233		0.102	0.199	0.289	0.174
0.496	0.490	0.502	0.547		0.385	0.484	0.543	0.466

0.124	0.104	0.110	0.106	0.074	0.089	0.141	0.182	0.131
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ERA-I	ERA5	JRA55	MERRA2	Sonde Avg	Sat Avg	Reanal Avg
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		-0.029		-0.124		
		-0.254		-0.193		
		-0.343		-0.233		
		-0.426		-0.357		
		-0.466		-0.404		
		-0.361		-0.253		
		-0.477		-0.382		
		-0.597		-0.667		
		-0.279		-0.308		
		-0.518		-0.480		
		-0.499		-0.542		
		0.005		0.041		
		-0.196		0.122		
		-0.788		-0.949		
		-0.296		-0.440		
		-0.103		-0.116		
		-0.695		-0.726		
		-0.661		-0.677		
		-0.597		-0.686		
		-0.187		-0.232		
		-0.195		-0.166		
0.082	0.016	-0.016		-0.101	-0.154	0.000
0.093	0.056	0.051	-0.007	0.059	-0.038	0.033
-0.086	-0.118	-0.116	-0.159	-0.124	-0.183	-0.131
-0.081	-0.113	-0.106	-0.181	-0.091	-0.161	-0.133
0.239	0.251	0.215	0.111	0.240	0.225	0.192
-0.376	-0.436	-0.418	-0.499	-0.463	-0.453	-0.451
-0.390	-0.430	-0.417	-0.544	-0.398	-0.464	-0.464
-0.228	-0.237	-0.235	-0.391	-0.249	-0.310	-0.288

0.289	0.325	0.296	0.149	0.306	0.265	0.257
0.044	0.079	0.020	0.029	0.008	-0.044	0.043
-0.366	-0.317	-0.373	-0.338	-0.371	-0.445	-0.343
0.047	0.124	0.043	0.048	0.090	-0.047	0.072
0.080	0.145	0.077	0.086	0.137	0.028	0.103
-0.099	0.009	-0.059	0.015	0.012	-0.092	-0.012
-0.106	-0.035	-0.079	-0.014	-0.061	-0.111	-0.042
-0.115	-0.075	-0.059	-0.012	-0.086	-0.091	-0.049
0.061	0.100	0.092	0.120	0.076	0.093	0.104
-0.160	-0.153	-0.132	-0.091	-0.159	-0.113	-0.125
0.026	0.043	0.064	0.129	0.012	0.090	0.079
0.529	0.603	0.622	0.675	0.569	0.661	0.633
-0.316	-0.293	-0.259	-0.249	-0.266	-0.212	-0.267
-0.246	-0.340	-0.222	-0.215	-0.234	-0.171	-0.259
-0.043	-0.149	-0.056	-0.022	-0.037	0.029	-0.076
0.118	0.072	0.144	0.183	0.132	0.202	0.133
0.182	0.129	0.186	0.251	0.177	0.245	0.189
0.093	0.030	0.087	0.170	0.103	0.136	0.096
0.263	0.161	0.255	0.313	0.250	0.272	0.243
0.176	0.100	0.129	0.146	0.166	0.150	0.125
0.114	0.095	0.053	0.087	0.055	0.114	0.078
-0.197	-0.197	-0.256	-0.224	-0.276	-0.197	-0.226
0.162	0.172	0.122	0.107	0.115	0.170	0.134
0.386	0.455	0.381	0.321	0.374	0.414	0.386
-0.064	-0.039	-0.084	-0.120	-0.130	-0.048	-0.081
-0.043	-0.055	-0.064	-0.098	-0.069	-0.033	-0.072
0.185	0.203	0.155	0.102	0.175	0.171	0.154
0.213	0.228	0.186	0.148	0.205	0.188	0.188
0.474	0.496	0.436	0.390	0.485	0.437	0.441
0.675	0.673	0.657	0.569	0.656	0.629	0.633
0.467	0.410	0.350	0.317	0.372	0.350	0.359
0.343	0.237	0.189	0.170	0.207	0.191	0.199
	0.542	0.483	0.499	0.496	0.469	0.508
0.110	0.113	0.109	0.125	0.113	0.136	0.113
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300-200 Tropics

	RAOBCOR	RICH	RATPAC A	ERA-I	ERA5	JRA55	MERRA2
1955							
1956							
1957							
1958	0.208	-0.06917	-0.112				
1959	-0.057	-0.2125	-0.596				
1960	-0.185	-0.25417	-0.509				
1961	-0.530	-0.55917	-0.682				
1962	-0.463	-0.47125	-0.519				
1963	-0.371	-0.38083	-0.632				
1964	-0.603	-0.56208	-0.622				
1965	-0.964	-0.93417	-0.792				
1966	-0.448	-0.42042	-0.216				
1967	-0.773	-0.71958	-0.579				
1968	-0.765	-0.7925	-0.662				
1969	0.042	-0.00167	-0.106				
1970	0.148	0.314583	-0.192				
1971	-1.394	-1.19333	-1.106				
1972	-0.566	-0.5175	-0.392				
1973	-0.118	-0.05	-0.139				
1974	-0.971	-0.81292	-0.846				
1975	-1.013	-0.83583	-0.812				
1976	-0.974	-0.99042	-0.812				
1977	-0.198	-0.28375	-0.149				
1978	-0.146	-0.20125	-0.229				
1979	-0.055	-0.08708	0.081	0.137	0.111		
1980	0.087	0.03	0.121	0.09	0.068		
1981	-0.227	-0.31917	-0.139	-0.207	-0.225		
1982	-0.240	-0.34625	-0.099	-0.32	-0.281		
1983	0.269	0.2275	0.244	0.188	0.268		
1984	-0.715	-0.74667	-0.722	-0.705	-0.709		
1985	-0.595	-0.64	-0.626	-0.727	-0.695		
1986	-0.207	-0.23292	-0.286	-0.376	-0.291		

1987	0.533	0.500417	0.581	0.472	0.545
1988	0.040	0.051667	0.104	0.069	0.122
1989	-0.592	-0.53375	-0.406	-0.547	-0.515
1990	0.092	0.120417	0.218	0.047	0.11
1991	0.170	0.11125	0.164	0.117	0.17
1992	-0.087	-0.15708	-0.146	-0.172	-0.08
1993	-0.099	-0.17458	-0.219	-0.208	-0.111
1994	-0.031	-0.13125	-0.159	-0.15	-0.08
1995	0.125	0.101667	0.028	0.11	0.132
1996	-0.150	-0.17958	-0.406	-0.18	-0.185
1997	0.154	0.057917	-0.059	0.146	0.162
1998	0.906	0.97375	0.741	0.934	0.964
1999	-0.459	-0.34542	-0.486	-0.376	-0.473
2000	-0.323	-0.19958	-0.426	-0.289	-0.495
2001	-0.056	0.037083	-0.106	0.022	-0.222
2002	0.307	0.350417	0.278	0.263	0.197
2003	0.328	0.3775	0.374	0.311	0.242
2004	0.185	0.239167	0.234	0.195	0.126
2005	0.432	0.54375	0.531	0.486	0.374
2006	0.186	0.37	0.278	0.327	0.202
2007	0.065	0.262917	0.188	0.201	0.198
2008	-0.579	-0.37208	-0.512	-0.376	-0.326
2009	0.138	0.319583	0.194	0.234	0.281
2010	0.389	0.555	0.641	0.622	0.669
2011	-0.328	-0.17917	-0.166	-0.111	-0.073
2012	-0.167	-0.01542	-0.119	-0.078	-0.052
2013	0.176	0.329583	0.214	0.289	0.31
2014	0.300	0.43375	0.281	0.352	0.387
2015	0.628	0.73375	0.644	0.707	0.71
2016	0.995	1.095833	1.051	1.057	1.046
2017	0.496	0.605417	0.538	0.447	0.548
2018	0.275	0.4075	0.307667	0.151	0.325
2019	0.752	0.881667	0.837667		

10.000	0.151	0.216	0.164	0.171	0.168	#DIV/0!	#DIV/0!
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		300-150 Tropics		
Sonde Ave	Reanalyses	RAOBCORE	RICH	RATPAC A
		1955		
		1956		
		1957		
0.009		1958	0.336875	0.02625
-0.288		1959	0.0715625	-0.13625
-0.316		1960	-0.0813542	-0.2227083
-0.590		1961	-0.4471875	-0.505625
-0.484		1962	-0.37	-0.4173958
-0.461		1963	-0.3263542	-0.3891667
-0.596		1964	-0.5069792	-0.5215625
-0.897		1965	-0.8857292	-0.89625
-0.361		1966	-0.4047917	-0.4096875
-0.691		1967	-0.6953125	-0.6667708
-0.740		1968	-0.7072917	-0.7489583
-0.022		1969	0.01802083	-0.0364583
0.090		1970	0.221875	0.3009375
-1.231		1971	-1.2984375	-1.1929167
-0.492		1972	-0.5988542	-0.6325
-0.102		1973	-0.1235417	-0.1077083
-0.877		1974	-0.8926042	-0.7869792
-0.887		1975	-0.9366667	-0.8064583
-0.926		1976	-0.9136458	-0.9090625
-0.210		1977	-0.2307292	-0.2928125
-0.192		1978	-0.1497917	-0.1957292
-0.020	0.124	1979	-0.0586458	-0.0792708
0.079	0.079	1980	0.048125	0.00645833
-0.228	-0.216	1981	-0.22125	-0.294375
-0.229	-0.3005	1982	-0.2248958	-0.3065625
0.247	0.228	1983	0.26604167	0.23729167
-0.728	-0.707	1984	-0.7134375	-0.731875
-0.620	-0.711	1985	-0.5903125	-0.6447917
-0.242	-0.3335	1986	-0.19625	-0.2384375

0.538	0.5085	1987	0.50739583	0.4578125
0.065	0.0955	1988	0.05302083	0.05666667
-0.511	-0.531	1989	-0.5178125	-0.4369792
0.143	0.0785	1990	0.12770833	0.1978125
0.149	0.1435	1991	0.20104167	0.18885417
-0.130	-0.126	1992	-0.05	-0.0815625
-0.164	-0.1595	1993	-0.0991667	-0.1584375
-0.107	-0.115	1994	-0.0135417	-0.1034375
0.085	0.121	1995	0.13770833	0.08479167
-0.245	-0.1825	1996	-0.1130208	-0.1892708
0.051	0.154	1997	0.19822917	0.06885417
0.874	0.949	1998	0.89947917	0.91385417
-0.430	-0.4245	1999	-0.4115625	-0.3505208
-0.316	-0.392	2000	-0.306875	-0.2221875
-0.041	-0.1	2001	-0.0627083	0.01552083
0.312	0.23	2002	0.25770833	0.3028125
0.360	0.2765	2003	0.24895833	0.30645833
0.220	0.1605	2004	0.13760417	0.20125
0.502	0.43	2005	0.3728125	0.49614583
0.278	0.2645	2006	0.09510417	0.29145833
0.172	0.1995	2007	-0.0069792	0.20552083
-0.488	-0.351	2008	-0.6084375	-0.3832292
0.217	0.2575	2009	0.04802083	0.24947917
0.528	0.6455	2010	0.33083333	0.51229167
-0.224	-0.092	2011	-0.3404167	-0.1714583
-0.101	-0.065	2012	-0.2344792	-0.0519792
0.240	0.2995	2013	0.0928125	0.26677083
0.338	0.3695	2014	0.2065625	0.3653125
0.669	0.7085	2015	0.51354167	0.6459375
1.047	1.0515	2016	0.86322917	0.98875
0.546	0.4975	2017	0.371875	0.5028125
0.330	0.238	2018	0.18583333	0.33020833
0.824		2019	0.61114583	0.751875

0.177	0.170	10.000	0.116	0.184	#DIV/0!
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ERA-I	ERA5	JRA55	MERRA2	Sonde Ave	Reanalyses
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				0.182	
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				-0.032	
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				-0.152	
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				-0.476	
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				-0.394	
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				-0.358	
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				-0.514	
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				-0.891	
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				-0.407	
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				-0.681	
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				-0.728	
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				-0.009	
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				0.261	
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				-1.246	
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				-0.616	
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				-0.116	
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				-0.840	
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				-0.872	
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				-0.911	
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				-0.262	
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				-0.173	
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	0.015			-0.069	0.015
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	0.027			0.027	0.027
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	-0.212			-0.258	-0.212
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	-0.293			-0.266	-0.293
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	0.237			0.252	0.237
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	-0.716			-0.723	-0.716
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	-0.661			-0.618	-0.661
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	-0.273			-0.217	-0.273
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0.495	0.483	0.495
0.124	0.055	0.124
-0.493	-0.477	-0.493
0.104	0.163	0.104
0.183	0.195	0.183
-0.061	-0.066	-0.061
-0.119	-0.129	-0.119
-0.086	-0.058	-0.086
0.118	0.111	0.118
-0.193	-0.151	-0.193
0.151	0.134	0.151
0.912	0.907	0.912
-0.429	-0.381	-0.429
-0.49	-0.265	-0.49
-0.21	-0.024	-0.21
0.177	0.280	0.177
0.206	0.278	0.206
0.113	0.169	0.113
0.347	0.434	0.347
0.178	0.193	0.178
0.225	0.099	0.225
-0.283	-0.496	-0.283
0.288	0.149	0.288
0.682	0.422	0.682
-0.024	-0.256	-0.024
-0.031	-0.143	-0.031
0.315	0.180	0.315
0.375	0.286	0.375
0.698	0.580	0.698
1	0.926	1
0.514	0.437	0.514
0.312	0.258	0.312
	0.682	

#DIV/0!	0.172	#DIV/0!	#DIV/0!	0.150	0.172
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250-100

	RAOBCORE RICH	RATPAC A	ERA-I	ERA5	JRA55	MERRA2
1955						
1956						
1957						
1958	0.614	0.334				
1959	0.432	0.159				
1960	0.111	-0.122				
1961	0.002	-0.137				
1962	-0.087	-0.222				
1963	0.033	-0.129				
1964	-0.010	-0.138				
1965	-0.449	-0.538				
1966	-0.169	-0.261				
1967	-0.319	-0.344				
1968	-0.472	-0.527				
1969	0.050	-0.018				
1970	0.417	0.337				
1971	-0.922	-0.995				
1972	-0.599	-0.768				
1973	-0.024	-0.142				
1974	-0.637	-0.683				
1975	-0.644	-0.660				
1976	-0.639	-0.592				
1977	-0.271	-0.257				
1978	-0.161	-0.164				
1979	-0.083	-0.049		-0.077		
1980	-0.053	-0.055		-0.005		
1981	-0.172	-0.197		-0.082		
1982	-0.029	-0.060		-0.099		
1983	0.391	0.378		0.394		
1984	-0.583	-0.586		-0.541		
1985	-0.511	-0.564		-0.504		
1986	-0.253	-0.291		-0.221		

1987	0.382	0.324			0.359
1988	0.078	0.056			0.187
1989	-0.306	-0.198			-0.365
1990	0.207	0.336			0.131
1991	0.295	0.354			0.262
1992	0.093	0.112			0.052
1993	0.066	0.029			0.021
1994	0.029	-0.046			-0.091
1995	0.150	0.025			0.099
1996	-0.132	-0.267			-0.279
1997	0.202	0.078			0.016
1998	0.802	0.736			0.694
1999	-0.220	-0.261			-0.212
2000	-0.298	-0.299			-0.456
2001	-0.179	-0.134			-0.332
2002	-0.020	0.037			-0.048
2003	0.049	0.115			0.034
2004	-0.029	0.041			-0.048
2005	0.127	0.236			0.139
2006	-0.034	0.126			0.072
2007	-0.152	0.010			0.193
2008	-0.520	-0.368			-0.171
2009	-0.131	-0.002			0.221
2010	0.227	0.345			0.578
2011	-0.221	-0.100			0.106
2012	-0.386	-0.219			-0.107
2013	-0.073	0.100			0.197
2014	-0.033	0.124			0.290
2015	0.279	0.425			0.550
2016	0.432	0.566			0.692
2017	0.111	0.246			0.398
2018	0.000	0.124			0.221
2019	0.338	0.457			

10.000	0.029	0.081	#DIV/0!	#DIV/0!	0.110	#DIV/0!	#DIV/0!
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		TTT			RAOBCOF RICH		RATPAC / ERA-I		ERA5	
Sonde Ave	Reanalyses				RAOBCOF RICH		RATPAC / UAH		RSSv4.0	
		1955								
		1956								
		1957								
0.474		1958			0.038	-0.101	0.024			
0.295		1959			-0.200	-0.245	-0.385			
-0.005		1960			-0.276	-0.286	-0.369			
-0.067		1961			-0.482	-0.591	-0.560			
-0.154		1962			-0.466	-0.503	-0.459			
-0.048		1963			-0.391	-0.413	-0.507			
-0.074		1964			-0.536	-0.594	-0.540			
-0.494		1965			-0.788	-0.966	-0.719			
-0.215		1966			-0.398	-0.452	-0.286			
-0.331		1967			-0.605	-0.752	-0.532			
-0.500		1968			-0.629	-0.825	-0.520			
0.016		1969			0.017	-0.034	-0.111			
0.377		1970			0.047	0.283	-0.199			
-0.959		1971			-1.090	-1.225	-0.915			
-0.684		1972			-0.459	-0.550	-0.380			
-0.083		1973			-0.137	-0.082	-0.124			
-0.660		1974			-0.815	-0.845	-0.695			
-0.652		1975			-0.796	-0.868	-0.702			
-0.615		1976			-0.782	-1.022	-0.722			
-0.264		1977			-0.212	-0.316	-0.202			
-0.163		1978			-0.188	-0.233	-0.238			
-0.066	-0.077	1979			-0.093	-0.119	-0.029	-0.104	-0.169	
-0.054	-0.005	1980			0.045	-0.002	0.023	-0.013	-0.075	
-0.184	-0.082	1981			-0.171	-0.351	-0.099	-0.172	-0.232	
-0.044	-0.099	1982			-0.202	-0.378	-0.170	-0.218	-0.281	
0.385	0.394	1983			0.180	0.195	0.200	0.207	0.160	
-0.585	-0.541	1984			-0.507	-0.779	-0.456	-0.408	-0.480	
-0.538	-0.504	1985			-0.453	-0.672	-0.461	-0.475	-0.539	
-0.272	-0.221	1986			-0.231	-0.265	-0.267	-0.252	-0.320	

0.353	0.359	1987	0.328	0.468	0.347	0.348	0.281
0.067	0.187	1988	0.017	0.020	0.048	0.015	-0.060
-0.252	-0.365	1989	-0.452	-0.566	-0.449	-0.464	-0.541
0.271	0.131	1990	0.026	0.088	0.023	-0.062	-0.125
0.325	0.262	1991	0.086	0.079	0.032	0.025	-0.031
0.103	0.052	1992	-0.116	-0.189	-0.132	-0.177	-0.211
0.047	0.021	1993	-0.096	-0.207	-0.132	-0.127	-0.150
-0.008	-0.091	1994	-0.061	-0.163	-0.071	-0.041	-0.062
0.088	0.099	1995	0.099	0.070	0.080	0.125	0.108
-0.199	-0.279	1996	-0.119	-0.212	-0.216	-0.050	-0.065
0.140	0.016	1997	0.040	0.026	-0.086	0.114	0.116
0.769	0.694	1998	0.657	0.942	0.578	0.748	0.757
-0.240	-0.212	1999	-0.334	-0.377	-0.400	-0.297	-0.257
-0.298	-0.456	2000	-0.222	-0.232	-0.306	-0.197	-0.148
-0.157	-0.332	2001	-0.009	0.005	-0.075	-0.002	0.066
0.008	-0.048	2002	0.231	0.318	0.205	0.208	0.302
0.082	0.034	2003	0.257	0.345	0.280	0.245	0.338
0.006	-0.048	2004	0.153	0.207	0.187	0.102	0.185
0.182	0.139	2005	0.357	0.512	0.422	0.303	0.379
0.046	0.072	2006	0.170	0.338	0.223	0.089	0.157
-0.071	0.193	2007	0.114	0.231	0.200	0.115	0.175
-0.444	-0.171	2008	-0.327	-0.404	-0.294	-0.288	-0.224
-0.067	0.221	2009	0.177	0.288	0.222	0.176	0.239
0.286	0.578	2010	0.412	0.523	0.564	0.411	0.465
-0.160	0.106	2011	-0.172	-0.211	-0.036	-0.125	-0.068
-0.303	-0.107	2012	-0.026	-0.047	0.020	-0.043	0.044
0.013	0.197	2013	0.197	0.298	0.222	0.137	0.221
0.046	0.290	2014	0.268	0.402	0.281	0.187	0.269
0.352	0.550	2015	0.517	0.702	0.538	0.407	0.498
0.499	0.692	2016	0.812	1.064	0.866	0.702	0.793
0.178	0.398	2017	0.465	0.573	0.477	0.352	0.438
0.062	0.221	2018	0.275	0.375	0.299	0.169	0.261
0.398		2019	0.624	0.850	0.684	0.511	0.617

0.055	0.110		0.147	0.216	0.160	0.128	0.179
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0.98587	1	0.97852	0.97511	0.93924
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JRA55 MERRA2 Sonde Av Reanalyses

NOAA UW ERA5 JRA55 MERRA2 Sonde Av Sat Avg Reanalyses Avg

			-0.092		-0.013		
			-0.395		-0.277		
			-0.424		-0.310		
			-0.598		-0.544		
			-0.558		-0.476		
			-0.509		-0.437		
			-0.670		-0.557		
			-0.718		-0.824		
			-0.388		-0.379		
			-0.672		-0.629		
			-0.590		-0.658		
			-0.052		-0.043		
			-0.231		0.043		
			-0.918		-1.077		
			-0.317		-0.463		
			-0.143		-0.114		
			-0.767		-0.785		
			-0.764		-0.789		
			-0.690		-0.842		
			-0.182		-0.243		
			-0.243		-0.220		
-0.245	-0.204	-0.009	-0.018		-0.080	-0.186	-0.013
-0.171	-0.103	-0.006	0.014	-0.043	0.022	-0.089	-0.011
-0.285	-0.245	-0.180	-0.160	-0.201	-0.207	-0.238	-0.180
-0.338	-0.300	-0.238	-0.212	-0.295	-0.250	-0.291	-0.248
0.102	0.128	0.175	0.146	0.033	0.192	0.144	0.118
-0.556	-0.517	-0.483	-0.445	-0.531	-0.581	-0.499	-0.487
-0.589	-0.542	-0.512	-0.476	-0.612	-0.529	-0.541	-0.534
-0.367	-0.313	-0.255	-0.231	-0.408	-0.254	-0.316	-0.298

0.255	0.308	0.333	0.332	0.169	0.381	0.294	0.278
-0.096	-0.043	0.067	0.017	0.033	0.028	-0.052	0.039
-0.588	-0.529	-0.395	-0.452	-0.407	-0.489	-0.535	-0.418
-0.161	-0.107	0.061	-0.024	-0.014	0.046	-0.116	0.007
-0.067	-0.019	0.091	0.025	0.039	0.066	-0.025	0.051
-0.247	-0.207	-0.097	-0.168	-0.083	-0.146	-0.209	-0.116
-0.185	-0.142	-0.063	-0.122	-0.040	-0.145	-0.146	-0.075
-0.087	-0.051	-0.048	-0.034	0.033	-0.098	-0.056	-0.016
0.095	0.133	0.122	0.091	0.145	0.083	0.116	0.119
-0.089	-0.041	-0.103	-0.106	-0.037	-0.182	-0.058	-0.082
0.100	0.136	0.077	0.076	0.166	-0.007	0.115	0.107
0.765	0.793	0.703	0.711	0.778	0.726	0.761	0.731
-0.281	-0.269	-0.354	-0.319	-0.315	-0.371	-0.275	-0.329
-0.170	-0.156	-0.311	-0.215	-0.210	-0.253	-0.163	-0.245
0.052	0.056	-0.114	-0.030	-0.004	-0.026	0.054	-0.049
0.306	0.295	0.162	0.226	0.260	0.251	0.298	0.216
0.357	0.317	0.209	0.261	0.323	0.294	0.328	0.265
0.246	0.179	0.082	0.130	0.209	0.182	0.182	0.140
0.480	0.376	0.279	0.366	0.419	0.430	0.377	0.355
0.268	0.156	0.121	0.145	0.153	0.243	0.157	0.139
0.280	0.158	0.153	0.114	0.142	0.181	0.167	0.136
-0.116	-0.232	-0.228	-0.283	-0.262	-0.342	-0.228	-0.258
0.339	0.226	0.237	0.194	0.157	0.229	0.233	0.196
0.577	0.451	0.510	0.443	0.360	0.500	0.458	0.438
0.040	-0.086	-0.054	-0.100	-0.159	-0.140	-0.077	-0.104
0.121	0.015	0.000	-0.003	-0.057	-0.018	0.029	-0.020
0.288	0.180	0.231	0.189	0.113	0.239	0.200	0.178
0.324	0.221	0.287	0.249	0.187	0.317	0.245	0.241
0.552	0.437	0.533	0.474	0.405	0.586	0.468	0.470
0.874	0.751	0.817	0.819	0.694	0.914	0.772	0.777
0.522	0.398	0.488	0.438	0.374	0.505	0.418	0.433
0.359	0.232	0.297	0.264	0.215	0.316	0.246	0.258
0.650	0.568	0.659	0.612	0.601	0.719	0.592	0.624

0.226	0.170	0.154	0.147	0.157	0.174	0.174	0.150
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#DIV/0!	#DIV/0!	0.99272	0.9854
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From: John Christy <climateman60@gmail.com>
Sent: Tuesday, May 20, 2025 9:12 PM
To: Ross McKitrick
Cc: Judith Curry; Roy W. Spencer; Steve Koonin
Subject: Re: Model-obs comparison in troposphere

Ross

I can reformat if you could send what you need.

John C.

Sent from my iPhone

On May 20, 2025, at 7:37 PM, Ross McKitrick <ross.mckitrick@gmail.com> wrote:

The updated data you sent are formatted very differently from the earlier spreadsheets and would take a lot of coding to get into the program.

On Tue, May 20, 2025 at 8:35 PM John Christy <climateman60@gmail.com> wrote:
Oh, I see through 2018.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 20, 2025, at 7:04 PM, Ross McKitrick <ross.mckitrick@gmail.com> wrote:

Is this better?

<image.png>

Figure 5.4: Observed versus modeled warming trends in the global lower (LT) and mid-troposphere (MT). Adapted from McKitrick and Christy (2020). Blue dots: warming trends (°C/decade 1979-2018) with 95% confidence interval bars

for 3 data products (satellite, radiosondes and reanalysis) and 95% confidence interval bars. Blue dashed line: warming trend average for 3 observed series. Red dots: modeled warming trends in 36 models.

From: Judith Curry [curry.judith@gmail.com]
Sent: 5/21/2025 12:59:00 AM
To: Ross McKittrick [ross.mckittrick@gmail.com]
CC: Roy W. Spencer [roywspencer@hotmail.com]; John Christy [climateman60@gmail.com]; Steven Koonin [steven.koonin@gmail.com]
Subject: Re: Model-obs comparison in troposphere

Yes, much better.

On Tue, May 20, 2025 at 5:04 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:
Is this better?

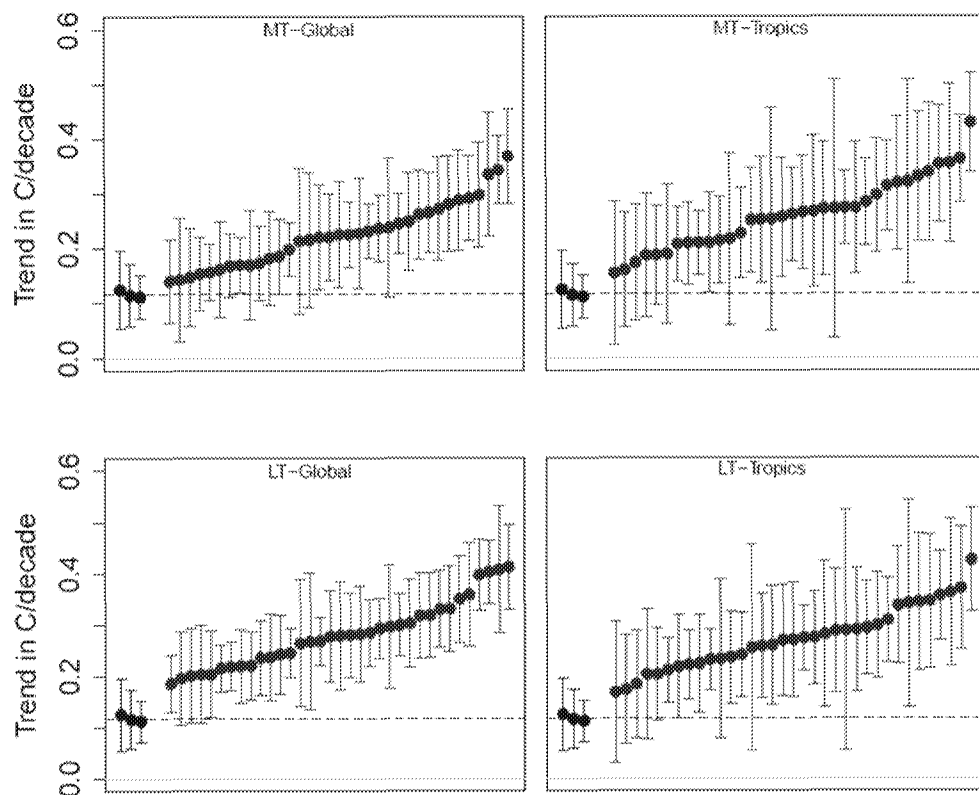
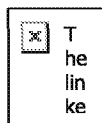


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Judith Curry, President
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<http://www.cfanclimate.net>



From: Ross McKittrick <ross.mckitrick@gmail.com>
Sent: Tuesday, May 20, 2025 8:38 PM
To: John Christy
Cc: Judith Curry; Roy W. Spencer; Steve Koonin
Subject: Re: Model-obs comparison in troposphere

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Subject: Re: Model-obs comparison in troposphere

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From: John Christy <climateman60@gmail.com>
Sent: Tuesday, May 20, 2025 8:34 PM
To: Ross McKittrick
Cc: Judith Curry; Roy W. Spencer; Steve Koonin
Subject: Re: Model-obs comparison in troposphere

Ross

Are these through 2024?

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 20, 2025, at 7:04 PM, Ross McKittrick <ross.mckitrick@gmail.com> wrote:

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From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 5/21/2025 12:04:30 AM
To: Judith Curry [curry.judith@gmail.com]; Roy W. Spencer [roywspencer@hotmail.com]; John Christy [climateman60@gmail.com]; Steven Koonin [steven.koonin@gmail.com]
Subject: Model-obs comparison in troposphere
Attachments: image.png

Is this better?

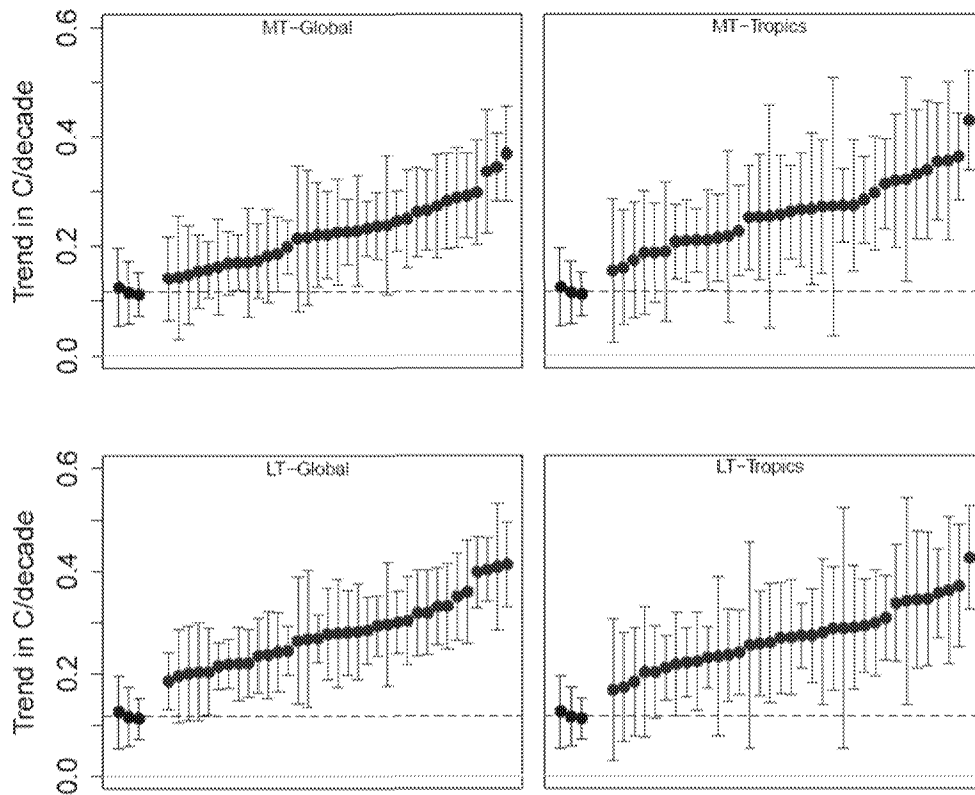


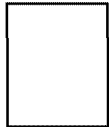
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From: Judith Curry <curry.judith@gmail.com>
Sent: Tuesday, May 20, 2025 11:21 AM
To: Steven Koonin
Cc: Ross McKittrick; John Christy; Roy Spencer; Travis Fisher
Subject: chapter 4 revisions
Attachments: 4 Climate SensitivityMay18 CURRY.docx

see attached

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4 Climate Sensitivity to CO₂ Forcing

Chapter Summary

There is growing recognition that climate models are not fit for the purpose of determining the Equilibrium Climate Sensitivity (ECS) of the climate to increasing CO₂. The IPCC has turned to data-driven approaches using historical data and paleoclimate reconstructions, but their reliability is diminished by data inadequacies.

Data-driven ECS estimates tend to be lower than climate model-generated values. The IPCC AR6 upper bound for the likely range of ECS is 4.0°C, lower than the AR5 value of 4.5°C. This lowering of the upper bound seems well justified by paleoclimatic data. The IPCC AR6 lower bound for the likely range of ECS is 2.5°C, substantially higher than the AR5 value of 1.5°C. This raising of the lower bound is more weakly justified. Evidence since the AR6 finds the lower bound of the likely range to be around 1.8°C.

4.1 Introduction

The climate's response to increasing concentrations of CO₂ is central to the scientific debate on anthropogenic climate change, and so also to the public debate on "climate action." The simplest measure of that response is the rise in the global average surface temperature, quantified by the Equilibrium Climate Sensitivity (ECS). ECS is defined as the amount of warming expected in response to a doubling of CO₂ from its pre-industrial concentration of 280 ppm, after all climate components have had time to adjust. Some components, like temperatures in the lower atmosphere (troposphere), adjust rapidly, while others such as the deep ocean and cryosphere might take as long as centuries. A related measure, the Transient Climate Response (TCR), better describes the shorter time scales; it is defined as the amount of warming when the CO₂ concentration is doubled by rising one percent annually for 70 years.

The 1979 Charney Report for the US National Academy of Sciences (Charney *et al.* 1979) proposed that the most likely ECS was $3.0 \pm 1.5^\circ\text{C}$. The IPCC repeatedly reaffirmed that range with only minor variations until its most recent AR6. AR5 termed 1.5 -- 4.5°C as the *likely* range (66 percent probability) and stated that ECS is *extremely unlikely* (95 percent probability) to be below 1.0°C and very unlikely (90 percent probability) to exceed 6.5°C.

The uncertainty in ECS has remained stubbornly wide, despite many individual studies that have claimed to narrow it. Most recently, AR6 narrowed the *likely* range to 2.5–4.0°C and deemed the *very likely* range to be 2.0 - 5.0°C. This narrowing on the low end is disputed, as will be discussed below.

Uncertainties in ECS are highly consequential for policy making. As will be discussed in Chapter 11, economic models use ECS values to project the costs of CO₂ emissions. The traditional value (3.0 °C) has typically yielded modest global social costs of CO₂ emissions, sufficient to justify some policy actions, but mostly deferred to later in this century. If ECS is very high (above 4.5°C) immediate aggressive emission controls become more imperative, whereas no CO₂ emission controls are economically justifiable for ECS below 2.0°C (Dayaratna et al. 2016, 2020). Obtaining a precise estimate is impossible, so policy making needs to account for the uncertainty.

Climate scientists use multiple lines of evidence to determine the Equilibrium Climate Sensitivity:

- Climate model simulations
- Historical observations
- Paleoclimatic observations

- Process understanding of feedbacks

By itself, the equilibrium warming effect of a doubling of atmospheric CO₂ is slightly more than 1°C.³³ The large values of ECS arise from positive feedbacks that amplify the warming effect of CO₂. Water vapor feedback is positive: a warmer atmosphere may have more water vapor, which itself is a powerful greenhouse gas. Water vapor feedback is partially canceled by the fact that atmospheric temperature decreases more slowly with height above the Earth's surface when atmospheric water vapor increases. Warmer temperatures also result in less snow and sea ice cover, allowing the Earth to absorb more of the sun's radiation. Some simple estimates of these three feedbacks increase the ECS to around 2°C.³⁴

Higher values of ECS arise primarily from positive cloud feedbacks. The magnitude, and even the sign, of cloud feedbacks is the greatest source of uncertainty. Elements of cloud feedback include changes in the latitudinal distribution of clouds, changes in the distribution of cloud height (changes in low versus high clouds), changes to the phase of clouds (ice versus liquid), changes in cloud particle size (associated with changes in concentration and/or composition of aerosol particles), changes in the precipitation efficiency of clouds, and even changes in how clouds are distributed over the daily solar cycle.³⁵

4.2 Model-based estimates of climate sensitivity

The ECS ranges given in IPCC AR4 and AR5 were obtained primarily by examining the behaviour of large-scale climate models, also called General Circulation Models (GCMs). However, the IPCC changed course in its AR6 when it turned to a more direct data-driven methodology. Here we discuss some of the pitfalls of using GCMs to try to determine the Earth's climate sensitivity.

ECS is an emergent property of climate models—that is, it is not directly parameterized or tuned. Historically, collections of parameterizations have been chosen to produce an expected value of climate sensitivity, particularly with regards to sub-grid-scale cloud processes, particularly in AR4 and to a lesser extent in AR5. Otherwise plausible GCMs and parameter selections have been discarded because of perceived conflict with this warming rate, or aversion to a model's climate sensitivity being outside an accepted range. For example, even in a CMIP6 model, Mauritsen and Roeckner (2020) state the following regarding their Max Planck Institute climate model (emphasis added):

“We have documented how we tuned the MPI-ESM1.2 global climate model to match the instrumental record of warming; an endeavor which has clearly been successful. Due to the historical order of events, the choice was to do this practically by *targeting an ECS of about 3 K using cloud feedbacks*, as opposed to tuning the aerosol forcing.”

In other words, the modelers chose an ECS value of 3°C and then tuned the cloud parameterizations to match their intended result.

~~Direct warming from CO₂ doubling is only about 1°C (Hall and Manabe 1997); further warming arises from climate feedbacks that are not explicitly resolved by the GCM but rely on parameterizations of physical processes. Higher values of ECS arise primarily from assumed positive cloud feedbacks, whereas the magnitude and even the sign of the feedbacks are very uncertain. Elements of cloud feedback include changes in the latitudinal distribution of clouds, changes in the distribution of cloud height (changes in low versus high clouds), changes to the phase of clouds (ice versus liquid), changes~~

in cloud particle size (associated with changes in concentration and/or composition of aerosol particles), changes in the precipitation efficiency of clouds, and even changes in how clouds are distributed over the daily solar cycle (Curry and Webster, 1999). It is difficult for GCMs to simulate any of these processes correctly owing to their small scale, let alone predict how they will change in the future. Further, cloud processes modulate the magnitudes of the water vapor, lapse rate, and the surface albedo feedbacks.

ECS can be determined from climate model simulations by doubling the concentration of CO₂ and allowing several centuries for the warming to equilibrate. To avoid the necessity of long simulations, “effective climate sensitivity” is commonly evaluated from a 150-year simulation in response to a sudden quadrupling of CO₂.

The spread of ECS values from the CMIP5 ensemble of climate models used in the AR5 was 2.0–4.7°C; that range increased for the CMIP6 models used in the AR6 to between 1.8 and 5.7°C (Chen et al, 2021, Scafetta 2021, see Figure 5.1). Far from converging, the model-based sensitivity of climate system uncertainties appear to be growing. The main cause of the overall upward shift in ECS in CMIP6 relative to CMIP5 is a larger positive cloud feedback, driven by changes to the cloud parameterizations in many CMIP6 models (Zelinka et al, 2020)

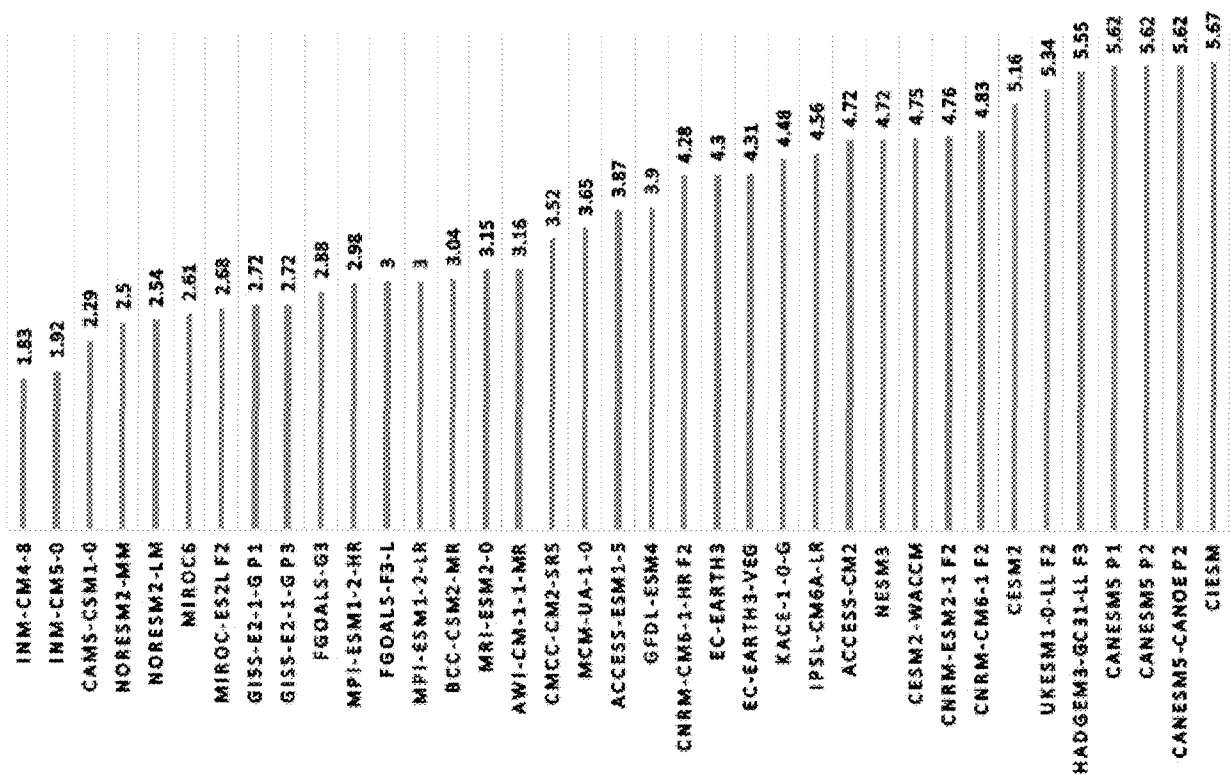


Figure 4.1 Equilibrium Climate Sensitivities in °C of 37 climate models from the CMIP6 ensemble. Identifiers for the various models appear along the horizontal axis. From (Scafetta, 2021) <https://www.mdpi.com/2225-1154/9/11/161>

Because of concerns about model tuning and the high sensitivity to cloud parameterizations, the IPCC AR6 (2021) did not rely on climate model simulations in their assessment of climate sensitivity, relying instead on other methods, chiefly a recent empirical estimate.

4.3 Data-driven estimates of climate sensitivity

Climate sensitivity can also be estimated from instrumental records of surface temperatures and ocean heat content, combined with estimates of how climate forcings (e.g., greenhouse gases, solar, volcanoes, aerosols) have changed in the past (Otto et al., 2013). Using this information, a simple empirical model called an Energy Balance Model can be employed. It requires estimating a feedback parameter whose uncertainties are highly amplified in the resulting ECS (Roe and Baker, 2007).

The accuracy of the data-driven methods depends on the quality of the input data. Assumptions are needed about ocean heat storage, and the ocean data is inadequate. The greatest source of uncertainty is the amount and composition of aerosol particles and their interactions with cloud radiative properties (the so-called aerosol indirect effect). Climate models exhibit warming in response to GHGs but cooling in response to aerosols (Schwartz et al. 2007). Observed 20th century warming can be shown to be consistent either with low ECS and low aerosol cooling, or high ECS and high aerosol cooling. Since fossil fuel use adds both GHGs and aerosols to the atmosphere, both effects need to be estimated to isolate the warming effect of CO₂. Over time, the IPCC's estimate of the cooling effect of aerosols has declined (Lewis 2022).

Paleoclimate proxies are also used to evaluate the sensitivity of past climates, by comparing paleoclimate changes in the Earth's temperatures to estimates of changes in forcings. The two most informative periods are the last glacial maximum (around 20,000 years ago), which was about 3–7°C colder than today, and a mid-Pliocene period (roughly three million years ago), which was 1–3°C warmer than today. The limits on cooling during the last glacial maximum give the best single evidence that high values of climate sensitivity are unlikely. However, paleoclimate estimates are associated with very large uncertainties in the estimated temperatures and forcings. Further, estimates of climate sensitivity based on past climate states may not be representative of the current state of the climate system.

A recurring theme in the climate literature is that ECS estimates based on historical data are smaller than ECS estimates inferred from climate models (Sherwood and Forest 2024). About 15 estimates based on historical data appeared in the peer-reviewed literature between 2012 and 2024 yielding ECS best estimates between 1.0°C and 2.5°C, although critics have questioned some of the methods and the data quality. For the AR6, the IPCC placed primary weight on the results of Sherwood et al. (2020) that combined historical and paleoclimate proxies with process-based understanding of feedbacks and yielded a best estimate of 3.1°C with a *likely* range of 2.6–3.9 °C. Lewis (2022) raised a number of concerns about this result, including methodological errors, outdated input values, and use of subjective versus objective Bayesian priors in the analysis. Lewis' analysis found that climate sensitivity is estimated to be much lower and better constrained than in the Sherwood et al. analysis – median 2.2°C (1.8–2.7°C in the 17–83 percent *likely* range, and 1.6–3.2°C in the 5–95 percent *very likely* range). The IPCC AR6 estimated only a 5 percent probability that ECS was below 2.3°C, whereas Lewis estimated it to be over 50 percent. The most recent publications on the debate between Sherwood et al. and Lewis further defend their respective positions: Sherwood and Foster (2024) and Lewis (2025).

An argument emphasized in AR6 is that data-driven ECS estimates might understate the future warming response to GHGs because of a so-called “pattern effect” (Forster et al 2021). The tropical

Pacific is believed to strongly influence the overall efficiency with which the Earth radiates heat to space, but some regions remove heat more efficiently than others. If the west-to-east temperature gradient in the tropical Pacific is weakened in a warming climate, warming would concentration where heat is less efficiently removed, raising ECS.

However, most climate models simulate that rising GHGs will weaken the east-west temperature gradient, which led the IPCC in the AR6 to conclude that data-driven ECS estimates understated the *future* ECS value. However, Seager et al. (2019) pointed out that, contrary to models, the east-west temperature gradient has been strengthening over time. They further argued that the mechanism predicting otherwise in climate models was based on a faulty characterization of oceanic dynamics and there is no reason to expect the gradient to weaken. A similar argument was recently made by Lee et al. (2024), who concluded that “the trajectory of the observed trend reflects the response to increasing GHG loading in the atmosphere”; in other words, GHG warming should lead to a future strengthening rather than a weakening of the temperature gradient. Increased efficiency of atmospheric cooling implies, if anything, that the future ECS in a warming climate may be *lower* than current estimates.

5.5 Transient Climate Response

The Transient Climate Response (TCR) provides a more useful observational constraint on climate sensitivity. TCR is the amount of warming that results when CO₂ is increased at an annual rate of 1 percent over a period of 70 years (i.e., doubled gradually). Relative to the ECS, observationally determined values of TCR avoid the problems of uncertainties in ocean heat uptake and the fuzzy boundary in defining equilibrium arising from a range of timescales for the longer-term feedback processes (e.g., ice sheets). TCR is more generally related to peak warming and better constrained by historical warming, than ECS. IPCC AR6 judged the *very likely* range of TCR to be 1.2–2.4°C. In contrast to ECS, the upper bound of TCR is more tightly constrained. For comparison, the TCR values determined by Lewis (2023) are 1.25 to 2.0°C, showing much better agreement with the AR6 values than was seen in a comparison of the ECS values.

As will be discussed in Chapter 6, a real-world ECS smaller than the model average is supported by studies that show climate models on average overestimate the observed surface and troposphere warming over the past 50 years. Lower sensitivities also align with evidence from consistent fingerprinting (Section 8), where model responses need to be downscaled to align with observed trends.

Mauritsen, T., & Roeckner, E. (2020). Tuning the MPI-ESM1.2 global climate model to improve the match with instrumental record warming by lowering its climate sensitivity. *Journal of Advances in Modeling Earth Systems* 12, e2019MS002037; <https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2019MS002037>

Zelinka, M. D., Myers, T. A., McCoy, D. T., Po-Chedley, S., Caldwell, P. M., Ceppi, P., et al. (2020). Causes of higher climate sensitivity in CMIP6 models. *Geophysical Research Letters*, 47, e2019GL085782. <https://doi.org/10.1029/2019GL085782>

1. Lan, X., Tans, P. and K.W. Thoning: Trends in globally-averaged CO₂ determined from NOAA Global Monitoring Laboratory measurements. Version Monday, 14-Apr-2025 09:08:57 MDT

<https://doi.org/10.15138/9N0H-ZH07>.

2. Zeke Hausfather, "Explainer: How Scientists Estimate Climate Sensitivity," *Carbon Brief*, July 22, 2020, <https://www.carbonbrief.org/explainer-how-scientists-estimate-climate-sensitivity>.
3. Jule Charney et al., "Carbon Dioxide and Climate: A Scientific Assessment," 1979, <https://doi.org/10.17226/12181>.
4. Rajendra K. Pachauri and Leo Meyer, *Climate Change 2014: Synthesis Report* (Geneva, CH: Intergovernmental panel on climate change, 2015).
5. "In-Depth Q&A: The IPCC's Sixth Assessment Report on Climate Science," Carbon Brief, August 9, 2021, <https://www.carbonbrief.org/in-depth-qa-the-ipccs-sixth-assessment-report-on-climate-science>.
6. Nicola Scafetta, "Testing the CMIP6 GCM Simulations versus Surface Temperature Records from 1980–1990 to 2011–2021: High ECS Is Not Supported," *Climate* 9, no. 11 (2021): 161, <https://doi.org/10.3390/cli9110161>.
7. Brian J. Soden and Isaac M. Held, "An Assessment of Climate Feedbacks in Coupled Ocean–Atmosphere Models," *Journal of Climate* 19, no. 14 (July 15, 2006): 3354–3360, <https://doi.org/10.1175/jcli3799.1>.
8. S. C. Sherwood et al., "An Assessment of Earth's Climate Sensitivity Using Multiple Lines of Evidence," *Reviews of Geophysics* 58, no. 4 (July 22, 2020), <https://doi.org/10.1029/2019rg000678>.
9. Judith A. Curry and Peter J. Webster, "Thermodynamic Feedbacks in the Climate System," in *Thermodynamics of Atmospheres and Oceans* (New York, NY: Academic Press, 1999), 351–385.
10. Rajendra K. Pachauri and Leo Meyer, *Climate Change*.
11. D. Chen et al., "Framing, Context, and Methods."
12. Mark D. Zelinka et al., "Causes of Higher Climate Sensitivity in CMIP6 Models," *Geophysical Research Letters* 47, no. 1 (2020): e2019GL085782, <https://doi.org/10.1029/2019GL085782>.
13. Thorsten Mauritsen and Johann Jungclauss, "Tuning the MPI-ESM1.2 Global Climate Model to Improve the Match With Instrumental Record Warming by Lowering Its Climate Sensitivity," *Journal of Advances in Modeling Earth Systems* 12, no. 7 (2020): e2019MS002037, <https://doi.org/10.1029/2019MS002037>.
14. Alexander Otto et al., "Energy Budget Constraints on Climate Response," *Nature Geoscience* 6, no. 6 (May 19, 2013): 415–416, <https://doi.org/10.1038/ngeo1836>.
15. Steven C. Sherwood and Chris E. Forest, "Opinion: Can Uncertainty in Climate Sensitivity Be Narrowed Further?" *Atmospheric Chemistry and Physics* 24, no. 5 (2024): 2679–2686, <https://doi.org/10.5194/acp-24-2679-2024>.
16. "Why Low-End 'Climate Sensitivity' Can Now Be Ruled Out," Carbon Brief, July 22, 2020, <https://www.carbonbrief.org/guest-post-why-low-end-climate-sensitivity-can-now-be-ruled-out>.
17. S. C. Sherwood et al., "An Assessment of Earth's Climate Sensitivity."
18. D. Chen et al., "Framing, Context, and Methods."
19. Nicholas Lewis, "Objectively Combining Climate Sensitivity Evidence," *Climate Dynamics* 61, no. 9–10 (2023): 3155–3163, <https://doi.org/10.1007/s00382-022-06398-8>.
20. Ibid.
21. Steven C. Sherwood and Chris E. Forest, "Opinion: Can Uncertainty in Climate Sensitivity Be Narrowed Further?"

22. Nicholas Lewis, "Comment on 'Can Uncertainty in Climate Sensitivity Be Narrowed Further?' by Sherwood and Forest (2024)," *EGUsphere* [preprint], 2025, <https://doi.org/10.5194/egusphere-2025-1179>.
 23. P. Forster et al., (2021): The Earth's energy budget, climate feedbacks, and climate sensitivity. In: *Climate Change 2021: The Physical Science Basis*. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V. et al. (eds.)], Cambridge University Press, 2021.
 24. Richard Seager et al., "Strengthening Tropical Pacific Zonal Sea Surface Temperature Gradient Consistent with Rising Greenhouse Gases," *Nature Climate Change* 9, no. 7 (2019): 517–522, <https://doi.org/10.1038/s41558-019-0505-x>.
 25. Sangyeop Lee et al., "Zonal Contrasts of the Tropical Pacific Climate Predicted by a Global Constraint," *Climate Dynamics* 62, no. 1–2 (2024): 229–246, <https://doi.org/10.1007/s00382-023-06741-7>.
 26. D. Chen et al., "Framing, Context, and Methods."
 27. Nicholas Lewis, "Objectively Combining Climate Sensitivity Evidence."
 28. Rajendra K. Pachauri and Leo Meyer, *Climate Change*.
 29. Nicholas Lewis, "Objectively Combining Climate Sensitivity Evidence."
 30. Nicholas Lewis, "Comment on 'Can Uncertainty in Climate Sensitivity Be Narrowed Further?' by Sherwood and Forest (2024)."
- Nierenberg, William et al. (1983) *Changing Climate: Report of the Carbon Dioxide Assessment Committee*. Washington, National Academies Press 1983.

From: Judith Curry [curry.judith@gmail.com]
Sent: 8/1/2025 8:41:32 PM
To: Steven Koonin [steven.koonin@gmail.com]
CC: Travis Fisher [travis.fisher@hq.doe.gov]; Ross McKittrick [ross.mckittrick@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; Charles Park [charles.park@hq.doe.gov]; John Christy [climateman60@gmail.com]; Joshua Loucks [Joshua.Loucks@hq.doe.gov]; Seth Cohen [seth.cohen@hq.doe.gov]; Audrey Barrios [audrey.barrios@hq.doe.gov]
Subject: Re: List of reviewers

We can add Palmer, although he has a single hobby horse. Won't do us any harm

On Fri, Aug 1, 2025 at 1:06 PM Steven Koonin <steven.koonin@gmail.com> wrote:
Did we discuss (and then reject?) Tim Palmer? He's international, of course, but so what.

Steven Koonin

On Aug 1, 2025, at 14:41, Judith Curry <curry.judith@gmail.com> wrote:

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Clara Deser (NCAR, NAS)

Graeme Stephens (NASA JPL, NAE)

Elizabeth Barnes (CSU, NASEM BASC; note she is also good with statistics)

Dan Shrag (Harvard, NAS?)

Richard Newell (economist)

Pielke Sr

(statistician)

(carbon cycle person)

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<image002.jpg>

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

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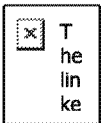
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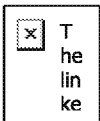
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From: Steven Koonin <steven.koonin@gmail.com>
Sent: Friday, August 1, 2025 4:06 PM
To: Judith Curry
Cc: Travis Fisher; Ross McKittrick; Roy Spencer; Charles Park; John Christy; Joshua Loucks; Seth Cohen; Audrey Barrios
Subject: Re: List of reviewers

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To: Fisher, Travis [travis.fisher@hq.doe.gov]
CC: Ross McKittrick [ross.mckittrick@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; Park, Charles [charles.park@hq.doe.gov]; John Christy [climatemanager60@gmail.com]; Steven Koonin [steven.koonin@gmail.com]; Loucks, Joshua [Joshua.Loucks@hq.doe.gov]; Cohen, Seth [seth.cohen@hq.doe.gov]; Barrios, Audrey [audrey.barrios@hq.doe.gov]
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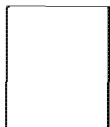
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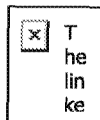
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Sent: Thursday, July 31, 2025 9:08 AM
To: Roy Spencer
Cc: Steven Koonin; John Christy; Ross McKittrick; Travis Fisher; Josh Loucks; Seth Cohen; andrea.woods@hq.doe.gov
Subject: Re: lots of moaning and crying about the DOE Climate Report

Decent article in science on this

<https://www.science.org/content/article/contrarian-climate-assessment-u-s-government-draws-swift-pushback>

On Thu, Jul 31, 2025 at 6:01 AM Roy Spencer <roywspencer@hotmail.com> wrote:

In the meantime, I think you all will enjoy today's blog post with some history behind all of this. Check out the graphic of us 5 "red team" researchers being surrounded by a swarm of blue team people with \$\$ raining down on them.

I made it clear the opinions stated therein are my own.

<https://www.drroyspencer.com/2025/07/some-thoughts-on-our-doe-report-regarding-co2-impacts-on-the-u-s-climate/>

From: Judith Curry <curry.judith@gmail.com>
Sent: Thursday, July 31, 2025 7:53 AM
To: Steven Koonin <steven.koonin@gmail.com>
Cc: John Christy <climateman60@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Josh Loucks <loucksj14@gmail.com>; Seth Cohen <seth.cohen@hq.doe.gov>; andrea.woods@hq.doe.gov <andrea.woods@hq.doe.gov>
Subject: Re: lots of moaning and crying about the DOE Climate Report

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On Wed, Jul 30, 2025 at 6:46 PM Steven Koonin <steven.koonin@gmail.com> wrote:

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Steven Koonin

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Date: July 30, 2025 at 19:36:23 MDT
To: Willie Soon <romeosoon@gmail.com>
Subject: lots of moaning and crying about the DOE Climate Report

<https://www.notus.org/climate-environment/scientists-trump-climate-change-report-doe-citations-mischaracterizations>

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<https://insideclimatenews.org/news/30072025/climate-scientists-fight-against-energy-department-report>

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From: Roy Spencer <roywspencer@hotmail.com>
Sent: Thursday, July 31, 2025 9:01 AM
To: Judith Curry; Steven Koonin
Cc: John Christy; Ross McKittrick; Travis Fisher; Josh Loucks; Seth Cohen; andrea.woods@hq.doe.gov
Subject: Re: lots of moaning and crying about the DOE Climate Report

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From: Judith Curry <curry.judith@gmail.com>
Sent: Thursday, July 31, 2025 8:54 AM
To: Steven Koonin
Cc: John Christy; Ross McKittrick; Roy W. Spencer; Travis Fisher; Josh Loucks; Seth Cohen; andrea.woods@hq.doe.gov
Subject: Re: lots of moaning and crying about the DOE Climate Report

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Sent: Wednesday, July 30, 2025 9:52 PM
To: Steven Koonin
Cc: John Christy; Judith Curry; Ross McKittrick; Roy W. Spencer; Josh Loucks; Seth Cohen; andrea.woods@hq.doe.gov
Subject: Re: lots of moaning and crying about the DOE Climate Report

I'll check on the progress tomorrow.

I'm hearing the federal register notice will run on Friday, so hopefully that also means the docket will open on the same day.

I'll run the traps and get back to you all.

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From: Steven Koonin <steven.koonin@gmail.com>
Sent: Saturday, August 2, 2025 5:08 PM
To: Ross McKittrick
Cc: Judith Curry; John Christy; Travis Fisher; Roy Spencer; Charles Park; Joshua Loucks; Seth Cohen; Audrey Barrios
Subject: Re: DOE Internal Reviews

I'll have a chance to look through these tomorrow.

Steven E. Koonin

On Aug 2, 2025, at 16:26, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I went through Judy's edited version and made a few more small changes, mostly changing any reference from "I" to "we" to emphasize the collective effort. The changes are in track changes mode.

Should these all be combined into a single file for release?

On Sat, Aug 2, 2025 at 12:36 PM Judith Curry <curry.judith@gmail.com> wrote:

YES we need to emphasize your point 2

Note: I am working with the Tropical ListServ (mostly hurricanes), including Kerry Emanuel and Jim Kossin. After initial antagonistic responses, i'm working with them to collect relevant data-based papers

On Sat, Aug 2, 2025 at 9:16 AM John Christy <climateman60@gmail.com> wrote:

I'll start looking at this today.

Note 1: Among the emails I've received was this from someone called Justin Bass, who said, "John, I would like to interview you about your willful ignorance concerning the excessive burning of oil, gas, and coal that causes more deadly and destructive flash flooding, wildfires, and hurricanes in the 21st century."

I think he should start by working on his own interview skills.

Note 2: The CWG may be an opportunity to demonstrate to the public that science is a bit slow and messy as we are using an orderly approach with open comments and responses to get to the truth ... a system that is in great contrast to the way things are done in the media with its deadlines and agendas.

John C.

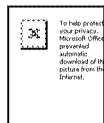
John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On Aug 2, 2025, at 9:48 AM, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I'll go over them later today

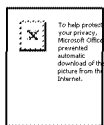
On Sat, Aug 2, 2025 at 10:37 AM Judith Curry <curry.judith@gmail.com> wrote:

Attached is a zip file of the edited DOE reviews. Probably good to have one more set of eyes look at this. Note: #1 and #6 required the most editing



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<DOE review responses.zip>

From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 8/2/2025 8:26:18 PM
To: Judith Curry [curry.judith@gmail.com]
CC: John Christy [climateman60@gmail.com]; Steve Koonin [steven.koonin@gmail.com]; Travis Fisher [travis.fisher@hq.doe.gov]; Roy Spencer [roywspencer@hotmail.com]; Charles Park [charles.park@hq.doe.gov]; Joshua Loucks [Joshua.Loucks@hq.doe.gov]; Seth Cohen [seth.cohen@hq.doe.gov]; Audrey Barrios [audrey.barrios@hq.doe.gov]
Subject: Re: DOE Internal Reviews
Attachments: DOE review responses.zip

I went through Judy's edited version and made a few more small changes, mostly changing any reference from "I" to "we" to emphasize the collective effort. The changes are in track changes mode.
Should these all be combined into a single file for release?

On Sat, Aug 2, 2025 at 12:36 PM Judith Curry <curry.judith@gmail.com> wrote:
YES we need to emphasize your point 2

Note: I am working with the Tropical ListServ (mostly hurricanes), including Kerry Emanuel and Jim Kossin. After initial antagonistic responses, I'm working with them to collect relevant data-based papers

On Sat, Aug 2, 2025 at 9:16 AM John Christy <climateman60@gmail.com> wrote:
I'll start looking at this today.

Note 1: Among the emails I've received was this from someone called Justin Bass, who said, "John, I would like to interview you about your willful ignorance concerning the excessive burning of oil, gas, and coal that causes more deadly and destructive flash flooding, wildfires, and hurricanes in the 21st century."

I think he should start by working on his own interview skills.

Note 2: The CWG may be an opportunity to demonstrate to the public that science is a bit slow and messy as we are using an orderly approach with open comments and responses to get to the truth ... a system that is in great contrast to the way things are done in the media with its deadlines and agendas.

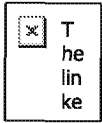
John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

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On Sat, Aug 2, 2025 at 10:37 AM Judith Curry <curry.judith@gmail.com> wrote:
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Pg	Para	Comment or Suggested Edit	
viii	2	The greening effect can't be due to increase in CO2 alone. The fertilization effect needs Nitrogen and phosphorous. There is observational[1] evidence that nitrogen available to plants is decreasing with increasing CO2 and thus acting to limit fertilization effect. Secondly, the greening of some portions of the planet are likely due to changes in precipitation patterns associated with changing climatic conditions and not entirely attributable to fertilization effect. We will also need to consider that the temperature effect on photosynthesis will also be a limiting mechanism to any continued greening due to fertilization in the future [2]. I recommend acknowledging that the greening is not attributable to CO2 alone and continued greening in the future with increasing CO2 is uncertain. Changed sentence to “Elevated concentrations of CO₂ directly enhance plant growth, globally contributing to “greening” the planet”	[1] Rachel E. Mason et al. Evidence, causes, and consequences of declining nitrogen availability in terrestrial ecosystems. Science 376, eabh3767(2022). DOI:10.1126/science.abh3767 [2] C.E. Moore, et al. The effect of increasing temperature on crop photosynthesis: from enzymes to ecosystems. Exp. Bot., 72 (8) (2021), pp. 2822-2844
viii	3	I am glad we acknowledge that CO2 causes warming, though I am not sure why we are not considering other energy sector related emissions that also cause warming (CFCs/HFCs, methane, aerosol effects). It is not clear what is meant by "CO2 emissions have tended to overestimate observed trends". This is not correct, the cumulative emissions track the RCP8.5 scenario the closest [3,4]. While there was a decrease in emissions during the Covid-19 period the emissions are now back on track following RCP8.5. This statement should clarify what is meant by the statement in the text. Rewrite sentence in the summary section to read “Climate change simulations require scenarios of distant future emissions. There is evidence that scenarios widely-used in the impacts literature have overstated observed and likely future emission trends.” On page 16 text added “Schwalm et al. (2020) defended the use of RCP8.5 on the grounds that cumulative CO2 emissions over 2005-2020 track it more closely than the lower RCP scenarios. They also argue that a modified version of the IEA scenarios closely track RCP8.5 in the coming decades. Hausfather and Peters (2020b) responded that the skill of RCP8.5 over those 15 years is due to offsetting errors in its representation of CO2 from fuel use and land use change, and the apparent agreement with IEA in coming decades is due to Schwalm et al. adding in very high land use emissions. The IEA’s own projected CO2 emissions track well below RCP8.5.”	[3] C.R. Schwalm, S. Glendon, & P.B. Duffy, RCP8.5 tracks cumulative CO2 emissions, Proc. Natl. Acad. Sci. U.S.A. 117 (33) 19656-19657, https://doi.org/10.1073/pnas.2007117117 (2020). [4] C.R. Schwalm, S. Glendon, & P.B. Duffy, Reply to Hausfather and Peters: RCP8.5 is neither problematic nor misleading, Proc. Natl. Acad. Sci. U.S.A. 117 (45) 27793-27794, https://doi.org/10.1073/pnas.2018008117 (2020).

viii	4	This paragraph seems to be talking about equilibrium climate sensitivity. The most recent model inter-comparison gives a wider range of climate sensitivities in the range of 1.8 to 5.7 and is wider than estimates of climate sensitivities that have been estimated from paleoclimatic and more recent historical datasets, in the range could be in the range of 2.3 to 4.5 K[5]. The higher sensitivity in the most recent model assessments are an area of active investigation by modelers, the feasibility of a higher range needs to be confirmed with additional observational and process scale modeling [6]. The range for climate sensitivities, 1.8-2.7, should be corrected to the most recent findings, 2.3-4.5. We should also recognize that the (a)earth is a complex system of systems (b)we can't do an experiment to find out what is correct or reduced the uncertainty. As we get better at extracting temperature records and CO2 concentrations from paelo data, there will be better reconstructions and possibly narrower range along with improvements in modeling that resolve many physical, biological and chemical processes as we get to higher and cloud resolving spatial resolutions. We discuss Sherwood et al. in Ch 4. Sentence changed: “Data-driven methods yield a lower and narrower range.”	[5] Sherwood, S. C., Webb, M. J., Annan, J. D., Armour, K. C., Forster, P. M., Hargreaves, J. C., et al. (2020). <u>An assessment of Earth's climate sensitivity using multiple lines of evidence</u>. <i>Reviews of Geophysics</i>, 58, e2019RG000678. https://doi.org/10.1029/2019RG000678 [6] Zelinka, M. D., Myers, T. A., McCoy, D. T., Po-Chedley, S., Caldwell, P. M., Ceppi, P., et al. (2020). <u>Causes of higher climate sensitivity in CMIP6 models</u>. <i>Geophysical Research Letters</i>, 47, e2019GL085782. https://doi.org/10.1029/2019GL085782
viii	5	This is again not true for the majority of the models in the AR6. Figure 7.19 in the IPCC AR6 report shows that majority of the models exhibit a range within the observational range. The models running hot in the most recent decades are the ones with climate sensitivities grate than 5K, which are 3 out of a total of 40 and it should be noted that about the same number of models also are running cold' compared to observed[7] Paragraph has been rewritten: The world’s several dozen global climate models offer little guidance on how much the climate responds to elevated CO , with the average surface warming under a doubling of the CO concentration ranging from 1.8°C to 5.7°C [Section 4.2]. Data-driven methods yield a lower and narrower range [Section 4.3]. Global climate models generally run “hot” in their description of the climate of the past few decades– too much warming at the surface and too much amplification of warming in the lower- and mid- troposphere [Sections 5.2-5.4]. The combination of overly sensitive models and implausible extreme scenarios for future emissions yields exaggerated projections of future warming.	[7]Hausfather, Z., Drake, H. F., Abbott, T., & Schmidt, G. A. (2020). <u>Evaluating the performance of past climate model projections</u>. <i>Geophysical Research Letters</i>, 47, e2019GL085378. https://doi.org/10.1029/2019GL085378
viii	5,6,7	There is very little dispute that these are challenging issues for climate science. Many of the issues identified here related to compound effects (subsidence and se-level rise; wildfire and forest management) that requires further scientific investigation. Identifying further research avenues/focus areas will be helpful to firm up some of the challenges faced in using the climate projections as discussed in the paragraph 9. There is no disagreement here.	

viii	9	The focus on uncertainty is relevant and should be emphasized in future research. However, as a reasonable policy pathways, making decisions in the face of these uncertainties is critical. Most of the climate uncertainties that we have confidence at this time can be considered Level 2 and Level 3 uncertainties, approaches such as scenario analysis (and others) are suggested and followed for making hazard and risk estimates for future conditions. For deep uncertainty hazards (for example tornadoes etc.) that we don't have enough data or capability to model, developing methods for assessing the uncertainty and risk should be a focus of future research. There is no disagreement here. See Curry's book Climate Uncertainty and Risk.	
2	3	The reason CO2 was identified as a pollutant is the health consequences of increased temperature, flooding and other climate impacts and not because of any direct affect on health dur to exposure to atmospheric CO2[8]. There is no disagreement here.	[8] https://www.cdc.gov/climate-health/php/effects/index.html
3	1/C hap ter su m ma ry	The summary should note that CO2 fertilization effects are limited by the availability of other critical plant nutrients (Nitrogen, Phosphorous). The fertilization effect is also constrained by higher temperature effecting photosynthesis[9] Added sentence: Other contributing factors included warming and increased nitrogen.	[9] Xinyuan Wei et al 2025 Environ. Res. Lett. 20 064013
3	3	The attribution of greening to primarily CO2 fertilization is questionable as per recent research. Specifically, in the Northern high latitudes (where the greening is most prominent), increases in temperatures due to climate change has been shown to provide the best explanation[10]. In the sub-Saharan region reforestation efforts and changing precipitation patterns lead to some of the observed greening (the great green wall) [11]. The attribution to CO2 fertilization should be qualified by noting the other present and emerging constraints. We cite Zhu et al attributing 70% of change to CO2 . That implies other factors matter as well.	[10]Liu, J., Wennberg, P.O. An emergent constraint on the thermal sensitivity of photosynthesis and greenness in the high latitude northern forests. Sci Rep 14, 6189 (2024). https://doi.org/10.1038/s41598-024-56362-1 [11] Francesco S.R. Pausata, Marco Gaetani, Gabriele Missouri, Alexis Berg, Danielle Maia de Souza, Rowan F. Sage, Peter B. deMenocal, The Greening of the Sahara: Past Changes and Future Implications, One Earth, Volume 2, Issue 3, 2020, Pages 235-250, ISSN 2590-3322, https://doi.org/10.1016/j.oneear.2020.03.002 .
3	5	This summarization ignores the compound effects of temperature, moisture and CO2 fertilization in assessing the impacts of CO2 increase on vegetation and crop yields. Many studies have shown that [12]. Making note of these compensating factors is required for a balanced view on CO2 fertilization effects on plants. This issue is addressed in Chapter 9	[12]Lesk, C., Anderson, W., Rigden, A. et al. Compound heat and moisture extreme impacts on global crop yields under climate change. Nat Rev Earth Environ 3, 872–889 (2022). https://doi.org/10.1038/s43017-022-00368-8

4	1	Chen et al. (2024)[13] conclude that "In the attribution analysis of LAI trend and growth rate trend, there were some differences between multiple linear regression model and partial correlation analysis at high latitudes in the northern hemisphere. Partial correlation analysis showed that LAI trend and growth rate trend in this region were mainly affected by temperature and radiation, while multiple linear regression suggested that CO2 was the dominant driver. The results of the partial correlation analysis seem more reasonable because some previous studies have shown that vegetation change in the high latitudes of the northern Hemisphere is mainly positively affected by climate warming. Multiple linear regression model performed relatively poorly in this region and might not fully identify the contribution of individual drivers. In addition, our model does not include the contribution of land management, which has been highlighted in some previous studies. Of course, the contribution of land management to LAI trend and growth rate trend may be implied in other drivers, such as the positive contribution of CO2 to LAI trend in PP and PN areas". We have added the Chen references. Our existing summary doesn't conflict with this. They conclude CO2 is the dominant driver globally but not the only driver.	[13]Xin Chen, Tiexi Chen, Bin He, Shuci Liu, Shengjie Zhou, Tingting Shi, The global greening continues despite increased drought stress since 2000, Global Ecology and Conservation, Volume 49, 2024, e02791,ISSN 2351-9894,
6	1	This again suffers from not acknowledging the effects of compound and often compensating phenomena that is occurring with the on-going climate change. For example [14] note that much of the Midwest any benefit from CO2 fertilization will be negated by temperature increases. [15] note that "Our results show that long-term physiological acclimation dampens the initial stimulation of plant net carbon assimilation to elevated [CO2], and of plant water use to warming." The topic of agricultural productivity is addressed in Chapter 9 It is not disputed that effects of dT go negative at high enough levels. The 2013 paper by Ruiz-Vera et al doesn't provide much general information beyond the FACE experiment site. The C14 data set I used is a global sample and takes both dT and dC into account.	[14]Ursula M. Ruiz-Vera, Matthew Siebers, Sharon B. Gray, David W. Drag, David M. Rosenthal, Bruce A. Kimball, Donald R. Ort, Carl J. Bernacchi, Global Warming Can Negate the Expected CO2 Stimulation in Photosynthesis and Productivity for Soybean Grown in the Midwestern United States , Plant Physiology, Volume 162, Issue 1, May 2013, Pages 410–423, https://doi.org/10.1104/pp.112.211938 [15] Lamba S, Hall M, Rantfors M, et al. Physiological acclimation dampens initial effects of elevated temperature and atmospheric CO2 concentration in mature boreal Norway spruce. Plant Cell Environ. 2018; 41: 300–313. https://doi.org/10.1111/pce.13079
8	1	The fallacy of these arguments in terms of PH changes and evolution is that the changes described in this paragraph occurred over millennia and the evolutionary process had time to adapt; here with climate change we are talking about changes in our lifetime, the speed of change is the issue. This will lead to collapse of some ecosystem and by the time adaptation takes place it will be millions of years and in a different climate - not the one we have now and that enabled the rise of humans. The chapter notes large regional and even diurnal variations in ocean pH. We already address the issue of short timescale variations on p. 8: "On the time scale of thousands of years, boron isotope proxy measurements show that ocean pH was around 7.4 or 7.5 during the last glaciation (up to about 20,000 years ago) increasing to present-day values as the world warmed during deglaciation (Rae <i>et al.</i>, 2018). Thus, ocean biota appear to be resilient to natural long-term changes in ocean pH since marine organisms were exposed to wide ranges in pH."	
5	Fig 2.2	A simple calculation will show us how misleading this figure is. It shows that over 600 Million years CO2 changed by around 6000ppm. That is a rate of change of 0.00001/yr; COE changed from 275 to 430 in the past 175 years, that is rate of change of 0.88ppm/yr. A change in the rate of over 10^5 in magnitude - there in lies the problem. We are seeing a rapid increase in CO2 that has never been witnessed and the ecosystem and huma society (which is at best 10K years old), may not be able to adapt to this rapid change. This figure has been deleted. We don't know what the rate of changes was on an annual or centennial time scale since the data are too low resolution. We have added the following sentence	

		“While the modern rate of change in CO2 is likely high compared to prior intervals, the geological evidence is that plants and animals evolved under much higher CO2 levels than at present.”	
12	Summary	The misuse of RCP8.5 as business as usual is acknowledged. However, this was never intended to be a no-policy or business as usual scenario but as a high-end baseline scenario. When dealing with interaction of physical systems with socio-economic projections (which tend to be highly uncertain and policy dependent), the development of this high baseline scenarios is intended to explore the uncertainty ranges that represent a high-end scenario[16,17]. As any engineer would acknowledge, this is a prudent approach when dealing with L3 and L4 type deep uncertainties and provide valid envelopes for assessing uncertainties and risks from high impact events/hazards. The rest of the statements here are uncertainties acknowledged by the climate scientists and included in developing projections and discussing the results[4]. Does the IPCC downplay the role of sun in climate change? The IPCC includes sun variability in all its assessments from the beginning and has been acknowledged as a potential but insignificant contributor. The comments do not imply any disagreement with what we have written. Extreme scenarios for models are useful for bracketing outcomes but our criticism (based on the literature) is the widespread use of RCP as a no-policy baseline; the reviewer acknowledges that was never its purpose. The IPCC’s assessment insignificance of the sun in climate change is based in part on use of low variability irradiance reconstructions that rule out it having any role. This is addressed in Chapter 8	[16]van Vuuren, D.P., Edmonds, J., Kainuma, M. et al. The representative concentration pathways: an overview. Climatic Change 109, 5 (2011). https://doi.org/10.1007/s10584-011-0148-z [17]Hausfather, Z. (2025). An assessment of current policy scenarios over the 21st century and the reduced plausibility of high-emissions pathways. Dialogues on Climate Change, 2(1), 26-32. https://doi.org/10.1177/29768659241304854 (Original work published 2025)
16	2,3,4,5	Please see above. The business-as-usual may be a misnomer but this is an 95% case that is typically included in any type of prudent uncertainty analysis, in particular given the difficulty of predicting the evolution of socio-economic and political conditions over the next 100 years. It should be noted the difference between RCP8.5 and RCP4.5 for mid-century conditions that is of particular focus for adaptation studies in not significant and most of the divergence in these two scenarios occurs later in the century. Implausibility is not equivalent to very unlikely (e.g. 95th percentile), but rather includes impossible or implausible assumptions. High impact hazards occur independent of atmospheric CO2 concentrations (Chapter 6).	

19	5	That the dynamic vegetation models need more development is acknowledged and is a defining challenge for Earth System Modeling for the next decade. There is no disagreement here	
22	3	As noted, Parker[18,19,20] has investigated the Urban effects on temperature records. The finding establish that by comparing warm and wind conditions world wide that the impact is negligible. However, as noted by authors, this literature hasn't progressed much over the last decade and much more attention needs to be paid to this question by employing newer models, datasets and analytical techniques available to us at present. The CWG Report addresses this concern. We agree with the reviewer that the literature stalled a decade+ ago.	[18] Parker, D. Large-scale warming is not urban. Nature 432, 290 (2004). https://doi.org/10.1038/432290a [19]Parker, D.E. (2010), Urban heat island effects on estimates of observed climate change. WIREs Clim Change, 1: 123-133. https://doi.org/10.1002/wcc.21. [20]Parker, D. E., 2006: A Demonstration That Large-Scale Warming Is Not Urban. J. Climate, 19, 2882–2895, https://doi.org/10.1175/JCLI3730.1.
28	2	We can all agree that there is a desperate need for developing higher-resolution climate models that can get to cloud resolving scale so that we can represent the cloud feedbacks correctly in the model and avoid uncertainties from parameterization and scale dependency of the parameters. This doesn't make these models useless. The models provide directions for further improvements and necessary changes to reduce the uncertainty bands over the ECS. The climate models are useful for research purposes. The CWG Report demonstrates that they are not fit for the purpose of policy making. There's no guarantee increased resolution will be the answer, but if ever a model appears that can deal correctly with clouds that will be quite something. .	

29	2	The databased approaches have mostly been robust with changes at the high end around 3-4C and at the low end around 1.8 to 2.5C as noted in the chapter. It will be challenging to make this range shorter given the data requirements and uncertainties in data over paleo/haloacene periods. It seems reasonable to estimate that we may have ECS in the range of 3 to 4K (higher than 3.5K being less likely [21]) at the higher end and this should not prevent us from planning and thinking on ways to prevent this possible scenario as it could have major consequences for humans across the planet. The Report acknowledges that 4C is a reasonable upper bound for the likely range	[21] Michael Mann, Our Fragile Moment: How lessons from Earth's past can help us survive climate crisis, Hachette Group Inc., 2024.
32	3	The models range over a factor of three in ECS comparing the most sensitive to the least sensitive models. However vast majority of the models are in 3 to 3.5K sensitivity range and it is probably not correct to assign all models the same amount of importance, given the fact that some of institutes participating in the exercise have different levels of capacity to develop and test models. Only 5 of the models are between 3 and 3.5C Some of the most reputable models have the highest values of ECS, including UK and US models The point made in this paragraph is that research over several decades has not reduced the range of model ECS. For observers who rely on model outputs this is very concerning and again goes to the question of fitness for purpose, as posed in the prior paragraph.	
34	1	While this analysis for the CMIP6 model set is accurate and focuses on a dataset that has shown higher ECS than previous iterations. it should be noted the models have exhibited considerable skill in predicting the subsequent GMST warming[22]. The criticism of the CMIP6 based high ECS models may be premature and probably will have to wait additional time before passing judgement. As noted in [22] these models have shown considerable skill when evaluated on their projections over the past 30-40 years after the projections were published. Figure 5.3 in the Report clearly refutes this assertion Hausfather et al. did examine early model-obs matches but only using models that had relatively low ECS. The Scaffeta analysis covered a longer interval (1980-2021) than the Hausfather et al. analysis of SAR (1995-2017) and TAR (2001-2017). Its findings line up with Fig 5.3 and the tropospheric evidence in Fig 5.4.	[22]Hausfather, Z., Drake, H. F., Abbott, T., & Schmidt, G. A. (2020). Evaluating the performance of past climate model projections. Geophysical Research Letters, 47, e2019GL085378. https://doi.org/10.1029/2019GL085378
36	1	A recent study attributes the bias to inter-annual availability and residual bias in the satellite record. The pre- and post 2000 have temperature records from two separate satellites and the discrepancy in the trends needs to be resolved[23] Chung et al. (using output through 2014 only) confirm the models' too-high warming rates and suggested two issues that might contribute to at least part of the discrepancy: (1) the differential phasing of natural, ephemeral events such as El Niños between models and observations and (2) a possible spurious cooling in UAH and NOAA/STAR satellite datasets around 2000. Regarding (1) we agree that the timing of major events like ENSOs diminishes the fidelity of models-to-observations comparisons for short periods, but now with 46 years of record as well as two major El Niño warm events since 2014 in the observations, the results shown in Fig. 5.7 are quite appropriate for comparison. Regarding (2) Christy et al. 2018 (and later Zou et al 2023) specifically examined the divergence around 2000 between UAH and NOAA/STAR vs. RSS and UW demonstrating that RSS and UW's use of the aging and drifting NOAA-14 satellite relative to the new, highly calibrated NOAA-15 sensor contributed to a spurious warming in RSS and UW. Be that as it may, CWG Fig. 5.7 is clear in noting all models overestimate the tropical temperature trend relative to observations – model trends being even more positive than those of RSS and the two Reanlayses (in addition to UAH and NOAA/STAR).	[23]Chung, ES., Kim, SJ., Sohn, BJ. et al. Multi-decadal climate variability and satellite biases have amplified model-observation discrepancies in tropical troposphere warming estimates. Commun Earth Environ 5, 342 (2024). https://doi.org/10.1038/s43247-024-01510-8

38	3	This is challenge we need to face and work on improving the parametrizations. The new era of super high resolution models would resolve the complex interactions of turbulence, transport and clouds and will provide less uncertainty[24]. However, this can't be used to invalidate the entire set of models, the models are performing remarkably well given the complex system that is being modeled. It should be noted the models do cover the range of the observations and it is not outside the envelope of model predictions. The Report does not address invalidating the entire set of models. Rather we address the fitness-for-purpose of the models for policy making Fig 5.6 shows that to the extent there is a match with observations, it comes from models with very little CO2 response. “However, this can't be used to invalidate the entire set of models, the models are performing remarkably well given the complex system that is being modeled.” This statement is not supported by the evidence unless and until “remarkably well” is metricized for us to examine and make a determination. The paper cited doesn’t exactly apply to the real world (looking at Fig 1 doesn’t give one much confidence in models), but does give insight into the various models as best I can tell.	[24]Merlis, T. M., Guendelman, I., Cheng, K.-Y., Harris, L., Chen, Y.-T., Bretherton, C. S., et al. (2024). The vertical structure of tropical temperature change in global storm-resolving model simulations of climate change. Geophysical Research Letters, 51, e2024GL111549. https://doi.org/10.1029/2024GL111549
40	4	Part of the problem here may be which part of the stratosphere is sampled and the importance of interannual a variabilities in the lower part of the stratosphere. [25] have shown that including the stratosphere as defined from 25 to 50km there is high confidence that the cooling signal caused by CO2 increase is detectable and beyond the noise levels of the natural and inter annual variability in the lowest part of the stratosphere. We should put this debate to rest. Santer et al. (2023 has been added to the references with this text: Santer et al. (2023) use updated data to show that a cooling trend has not re-emerged in the lower stratosphere.	[25] B.D. Santer, S. Po-Chedley, L. Zhao, C. Zou, Q. Fu, S. Solomon, D.W.J. Thompson, C. Mears, & K.E. Taylor, Exceptional stratospheric contribution to human fingerprints on atmospheric temperature, Proc. Natl. Acad. Sci. U.S.A. 120 (20) e2300758120, https://doi.org/10.1073/pnas.2300758120 (2023).
42	2	Given the large uncertainties in obtaining data over much of the Northern Hemisphere, using a smaller regional analysis to discount the models may be inappropriate. We should that this remains a question we need to resolve developing better datasets with more seasonal and sub-seasonal coverage to test the model on a global scale The reviewer’s points are fine but it is important in the context of this report to point out discrepancies in the way models on some key continental-scale metrics such as, in this case, snow cover. This section directly addresses a region that is important to estimates of the Social Cost of Carbon in the context of agricultural productivity, again reiterating that the models are not fit for the purpose of policy making.	

44	3	This statement from [26] refers to the fitness of global scale models to resolve regional scale features and argues for developing model at higher spatial resolutions. Using downscaling and other techniques additional insights can be gained at regional scales and provide information for a set of 'purposes'. However, we should work on getting to regional and local scales with GCM as quickly as possible. The current model structural forms may not be adequate for resolving all of these issues merely by increasing spatial resolution. Simulating change at regional to local scales depends on getting the internal variability of the ocean correct, which is only partly a resolution issue.	
47	2	Looking for trends or estimating trends in extreme events in current and future climate is not necessarily an attribution study. Estimating frequency, duration and intensity of events helps understand the changing range of the hazard (if there is one). An attribution would be to find to what extent a particular event is influenced or affected by increase in CO2. I would consider these two not to be the same. We explain the distinction between detection and attribution	
47	3	Attributing any single event to changing climate is perilous, agreed. Yes. .	
47	5	As noted by [26] there is not yet any strong evidence that LPT is a fact We have eliminated mention of LPT explicitly, but retain elements of the text surrounding long term variability.	[26]Cohn, T. A., and H. F. Lins (2005), Nature's style: Naturally trendy, Geophysics. Res. Lett., 32, L23402, doi:10.1029/2005GL024476.
57	2	I am not sure how one can conclude that the temperature extremes have decreased based on figure 6.3.4. If I understand correctly the Tmax-Tmin for each year was tabulated and a mean of this difference averaged over the 100+ years was subtracted from these values to get some thing like a anomaly. This anomaly seems to have moved from +3F to -3F over the course of q00 years and now trending upwards again. This suggests to me that there has been significant changes in the extremes over the years and the most recent trend is towards warmer highs? For each station and each year, the hottest day and coldest night are determined and their difference computed. These differences are then geographically averaged for the CONUS and then an overall average is removed to show the results as a type of anomaly. Reviewer 1 is correct, as indicated in the text, Tmin temperatures are almost universally rising more rapidly than Tmax, hence, the difference (or range) has declined overall. A check of CMIP6 models for the CONUS under ssp4.5 shows half with TMax rising faster than TMin and (obviously) half vice versa – so there is no clear signal from models that matches the observations. The flattening (or slight rise in the metric) in the past 20 years is clearly within the natural range, but does reveal an interesting stair-step pattern with rapid declines centered around the 1940's and 1990's and relatively flat periods in between. An explanation is under investigation, and a leading hypothesis is that there was rapid growth of manufactured surfaces around weather stations in the 1940s.	

		Then, in the 1960s-80s many stations were re-located to relatively rural airports, which then experienced subsequent growth in manufactured surfaces around their weather stations in the 1990s. Thus, rapid nighttime warming in the 1940s and 1990s.	
58	3	The NCA5 is suggesting that the western US is experiencing increase in extreme heat (page 57, para 4); it seems like figure 6.3.5 establishes the fact and not contradict. There was no claim of pervasive (all CONUS) increase in the report We have deleted the sentence “The NCA5 heading “The Risk of Temperature Extremes is Changing” suggests pervasive positive trends are now being observed in threshold temperatures, but that is not evident in the figures above.”Not worth going into more detail in this report	
59	4	The definition of heat wave as consecutive 6 days seems to be a special case. The standard definition is exceedance of 85 or 90 percentile for 2 or more days. I can't check with NCA5 as it was taken down from the web As correctly suggested by Reviewer 1, there are numerous ways to define a heat wave. CWG chose to follow one definition discussed in NCA4 (pg 191) and use 6 consecutive days with Tmax > 90th percentile so as to allow for consistent comparisons. However, changing the parameters will do little to alter the fundamental result that the 1920's to early 1950's contain the major heat wave events for the CONUS.	
60	1,2	Figure 6.3.6 establishes that heatwaves as defined here have increased in the west and have shown increasing trend all over CONUS in the past 50 years. [27] shows the results for the last 60 years and there is little doubt that there is an increase over most of the CONUS, again the NCA5 report is off the web; figure 6.3.7 shows the heat waves are monotonically increasing from the 1960. Including the longer data is only interesting in the dust bowl 1930 camouflage the signal somewhat for the Midwest and central plains. The problem of taking averages over large regions (for example entire CONUS) is that it kills the peak signals and smooths out the emergent climate change indicators. Doing continental averages to look for extremes is really not very useful. Secondly, there is no particular reason to assume that the climate change signal (i.e. the number of heat waves) should showing up 100 years ago, as the CO2 in the atmosphere started to be of significance in the last 50 years. As discussed in the CWG text, the EPA chart is (1) based on nighttime temperatures in the 50 largest US cities and (2) begins in 1961 which was the start of the coolest decade in over 100 years, thereby preconditioning the chart to have an upward trend. Urbanization is most clearly seen in nighttime temperature increases so this does not represent a change in the background climate, but more likely the local climates of cities. Rural areas show less nighttime warming. And, avoiding earlier warm periods does not provide information on the larger scale of natural variability. We have added a sentence at the end of Section 6.3 “Irrespective of the ultimate cause of regional trends, heatwaves have important effects on society which must be addressed, as we discuss in Chapter 10.”	[27] https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves

61	4	averaged over all stations in the region, none of these trend parameters is statistically significant'. This is again how one would be looking at statistics of extremes in precipitation. As we know, precipitation is highly heterogenous and location dependent. As observed there are trends even with the approaches chosen by the authors of this study compared to NCA5 and averaging that over and saying there is no trend seems disingenuous. We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area.	
62	2	same argument as above We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area.	
63	box	again the issue here is that we are talking about events that are happening in a short-time and over a small region. Averaging over time and space and develop statistics is probably not appropriate when we are talking about events such as the recent flooding event in Texas. If you average that event over 30 days, it will seem unremarkable. Extreme event totals are 1-day to 5-day,s depending on section discussed. The point being made in the Box is that if you use a too-short record you may underestimate natural variability. I'm not sure how the reviewer's comment challenges this.	
64	1	As noted in NCA5 and shown in the analysis presented in figure 6.4.4 there is a clear trend of increase in extreme precipitation in 12 of the 27 stations analyzed. Again averaging over the entire region is not the best method for picking extreme precipitation events that are local both in time and space. We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area. Also in this case we point out that the NE behaves differently than other regions.	

69	2	However, there is evidence that flash droughts, which last weeks have increased over the Northeast and Midwest [28] The paper referenced by Reviewer 1 begins with data so recent (1999) that it cannot provide evidence for long-term changes in drought as evidenced in the US Drought Monitor (DM) even though it suggests an increase in "flash droughts" over that period. Keep in mind, the DM is a product of subjective interpretation and objective measures - objective measures that have changed considerably during the past 25 years – thus is not metrically consistent. (One of the CWG authors was an official contributor to the DM for 15 years.) One would wonder what would the 1920's. 30's and early 50's reveal if the DM was operational back then? A more consistent metric is provided in CWG Fig. 6.7.1.	[28]Ronald D. Leeper, Rocky Bilotta, Bryan Petersen, Crystal J. Stiles, Richard Heim, Brian Fuchs, Olivier P. Prat, Michael Palecki, Steve Ansari
70	2	More recent analysis indicate forest loss due to wildfire accelerating over the recent past[29]. In particular there has been an increase in extreme fire radiative power with a 2 fold increase from 2003 to 2023 (period of satellite data availability)[30][31]. However, that these fires are not out-of-sample and there is a fire deficit as shown in figure 6.8.2 should be acknowledged. But this doesn't alleviate the concern that wildfire is leading to lot of socio-economic concerns and needs to be addressed[32] New sentence added: However there is evidence that the intensity of fires in some regions is worsening (Cunningham et al. 2024) and that wildfires resulted in a net loss of global forest cover over 2001-2019 (Tyukavina et al. 2022).	[29]Tyukavina Alexandra , Potapov Peter , Hansen Matthew C. , Pickens Amy H. , Stehman Stephen V. , Turubanova Svetlana , Parker Diana , Zalles Viviana , Lima André , Kommareddy Indrani , Song Xiao-Peng , Wang Lei , Harris Nancy; Global Trends of Forest Loss Due to Fire From 2001 to 2019, Frontiers in Remote Sensing.Volume 3 – 2022,2022. [30]Cunningham, C.X., Williamson, G.J. & Bowman, D.M.J.S. Increasing frequency and intensity of the most extreme wildfires on Earth. Nat Ecol Evol 8, 1420–1425 (2024). https://doi.org/10.1038/s41559-024-02452-2 [31]Patrick H. Freeborn, W. Matt Jolly, Mark A. Cochrane, Gareth Roberts, Large wildfire driven increases in nighttime fire activity observed across CONUS from 2003–2020, Remote Sensing of Environment, Volume 268, 2022,12777 [32]Parks, S.A., Guiterman, C.H., Margolis, E.Q. et al. A fire deficit persists across diverse North American forests despite recent increases in area burned. Nat Commun 16, 1493 (2025). https://doi.org/10.1038/s41467-025-56333-8
71	3	The question of forest management and its role on wildfire frequency and intensity is interesting and deserves further study. We agree	
80	1	The global mean sea-level was increasing at a rate of 0.08 inches/yr in 1993 compared 0.18 inches/yr in 2023, almost double the rate[33], which is approximately what is needed to meet the NOAA projections by mid-century and seems plausible. We don't judge it to be implausibl	[33]Hamlington, B.D., Bellas-Manley, A., Willis, J.K. et al. The rate of global sea level rise doubled during the past three decades. Commun Earth Environ 5, 601 (2024). https://doi.org/10.1038/s43247-024-01761-5

88	3	A possible reason the method used by IPCC (optimal fingerprinting) can be considered to address McKitnick criticism is in [34] We have added citation Chen et al. They mostly just reiterate my points. They propose a resolution to one part of the problem but it requires very restrictive assumptions.	[34]Chen, H., Chen, S.X. & Mu, M. A statistical review on the optimal fingerprinting approach in climate change studies. Clim Dyn 62, 1439–1446 (2024). https://doi.org/10.1007/s00382-023-06975-5
92	4	The role of clouds remains the single most uncertainty in climate modeling, I am glad this was acknowledged here. Agreed	
93	3	The substance of this paragraph was addressed in my comments in earlier sections. Some of the claims made here are either exaggerations of the usual practice (RCP8.5 being referred to as BAU) or the comment about not fit for purpose (a comment extracted from a publication that is calling out for cloud resolved models. Presumably the reviewer agrees RCP8.5 should not be used as a BAU scenario, so we are in agreement. The Palmer and Stevens paper nonetheless says the models are not currently fit for purpose.	
105	2,3, 4,5	The problem with both the FACE studies and the soybean. Maize and wheat studies cited here are that they don't consider the effect of increase in temperature, changes in precipitation, humidity and other environmental factors along with CO2 increases. These compound effects have been shown in wide number of studies [35] [36][37][38][39]. A meta analysis of the compound effects shows that increase in CO2, along with temperature, precipitation changes effects the quality of the cereal and yields[40]. Another recent study evaluated the impacts on C3 and C4 crops and conclude that CO2 enrichment for C3 crops could increase but will be compensated by temperature increase. CO2 fertilization effect was found to be small for C4 [41]. It is important therefore that we consider the compound effects on crop yields and not just focus on CO2 enrichment. The reviewer is correct that compound effects need to be considered, and indeed one of the problems with a lot of econometric papers on climate change and agriculture is they only look at heat and ignore the CO2 enrichment (Taylor and Schlenker being an important exception). Since our remit was impacts of CO2 emissions a brief discussion of FACE plot experiments and other CO2-only experiments is on topic. We discuss meta-analysis of multivariate (compound) experiments in Section 9.3.	[35] Ruiz-Vera UM, Siebers M, Gray SB, Drag DW, Rosenthal DM, Kimball BA, Ort DR, Bernacchi CJ. Global warming can negate the expected CO2 stimulation in photosynthesis and productivity for soybean grown in the Midwestern United States. Plant Physiol. 2013 May;162(1):410-23 [36] Levine LH, Richards JT, Wheeler RM. Super-elevated CO2 interferes with stomatal response to ABA and night closure in soybean (Glycine max). J Plant Physiol. 2009 Jun 1;166(9):903-13. [37]Večeřová K, Oravec M, Puranik S, Findurová H, Veselá B, Opoku E, Ofori-Amanfo KK, Klem K, Urban O, Sahu PP. Single and interactive effects of variables associated with climate change on wheat metabolome. Front Plant Sci. 2022 Oct 10;13:1002561. [38]Thomas, J.M.G., Boote, K.J., Allen, L.H., Gallo-Meagher, M. and Davis, J.M. (2003), Elevated Temperature and Carbon Dioxide Effects on Soybean Seed Composition and Transcript Abundance. Crop Sci., 43: 1548-1557. https://doi.org/10.2135/cropsci2003.1548 [39] Lesk, C., Anderson, W., Rigden, A. et al. Compound heat and moisture extreme impacts on global crop yields under climate change. Nat Rev Earth Environ 3, 872–889 (2022). https://doi.org/10.1038/s43017-022-00368-8 [40] Ben Mariem S, Soba D, Zhou B, Loladze I, Morales F, Aranjuelo I. Climate Change, Crop Yields, and Grain Quality of C3 Cereals: A Meta-Analysis of [CO2], Temperature, and Drought Effects. Plants. 2021; 10(6):1052. https://doi.org/10.3390/plants10061052 [41]Rezaei, E.E., Webber, H., Asseng, S. et al. Climate change impacts on crop yields. Nat Rev Earth Environ 4, 831–846 (2023). https://doi.org/10.1038/s43017-023-00491-0

106	1	Taylor and Schlenker 2021 also note that 'Climate change will likely have negative impact on agriculture in aggregate, especially in regions exposed to extreme heat. And the CO2-driven yield increases may be offset by effects on food nutrition and quality'. However, the results for US have been a net positive in the recent past but not true in the lower latitudes. Extreme heat may be a net negative, but thus far the overall effects have been positive. Regarding nutrition loss see Section 9.4	
111	1,2	The criticism of NOAA Billion dollar map is likely warranted as it was never completely transparent how the data was generated. However, changing the baseline assumption and refactoring the data using a different set of criteria to make the effects smaller also doesn't make sense. We should continue collecting this data and make the data accessible for researchers and peer review. Figure 10.1 doesn't address these issues, it is another methodology with unknown provenance of the data. We agree that data collection, dissemination and transparency are key. Fig 10.1 is traceable as an indicator though we don't regard it as the final word on the subject either. •	
117	3	Climate change can be expected to increase cold weather extremes in regions that have not been exposed to these effects Not sure what the reviewer's point is.	
118	3	The same Nobel prize winning model in its most recent study concludes that [42] "We conclude with three results relevant for climate policy. First, both current policies (base run) and the extended Paris Accord fall short of limiting global warming to 2 °C or to the cost–benefit optimal level. Second, the economic stakes in global climate policy are substantial, with estimated net present value of economic benefits around \$120 trillion from the cost–benefit optimal policy. Third, once differences in discounting are considered, the baseline DICE-2023 estimate of the social cost of carbon (\$66/tCO₂ for 2020) aligns closely with other recent estimates". Obviously this is the latest and the current version of the model and these results are quite different from thus discussed on this page. These conclusions should also be included in this discussion to avoid selective reading of the literature. We discuss Barrage and Nordhaus (2024) on p. 121.	[42]L. Barrage, & W. Nordhaus, Policies, projections, and the social cost of carbon: Results from the DICE-2023 model, Proc. Natl. Acad. Sci. U.S.A. 121 (13) e2312030121, https://doi.org/10.1073/pnas.2312030121 (2024).

120	1	Similar empirical studies [43] point to "Using an empirical approach that provides a robust lower bound on the persistence of impacts on economic growth, we find that the world economy is committed to an income reduction of 19% within the next 26 years independent of future emission choices (relative to a baseline without climate impacts, likely range of 11–29% accounting for physical climate and empirical uncertainty). These damages already outweigh the mitigation costs required to limit global warming to 2 °C by sixfold over this near-term time frame and thereafter diverge strongly dependent on emission choices. Committed damages arise predominantly through changes in average temperature, but accounting for further climatic components raises estimates by approximately 50% and leads to stronger regional heterogeneity. Committed losses are projected for all regions except those at very high latitudes, at which reductions in temperature variability bring benefits. The largest losses are committed at lower latitudes in regions with lower cumulative historical emissions and lower present-day income". This study uses more of the daily temperature precipitation from 1600 hundred locations world wide instead of global means. There are numerous studies that show the cost, many described in the COP 21 and follow-on meetings The Kotz et al. paper is subject to a cautionary notice at the Nature website that “the reliability of data and methodology presented in this manuscript is currently in question.” https://www.nature.com/articles/s41586-024-07219-0 The literature showing growth effects of temperature increase is pretty robust. And though we don’t cite it, there is a new paper just accepted at Climate Change Economics by McKittrick and Devina Lakhtakia adding to the evidence using 2 newly-constructed global data bases.	[43] Kotz, M., Levermann, A. & Wenz, L. The economic commitment of climate change. Nature 628, 551–557 (2024). https://doi.org/10.1038/s41586-024-07219-0
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Page	para	Comment or Suggested Edit
		The report indicates numerous examples of uncertainties in climate science. It would be extremely helpful if these uncertainties were made more explicit, listed in a concluding section, and prioritized in some way - what are the top 10 priority research areas? If the opening remarks by Secretary Wright and the title pointed to uncertainties and the need for more research, I believe this report will be better received. As I read the report and left review comments below, I bolded items where I gather the authors imply that research is needed. Consider including these kinds of statements throughout and adding a summary. An interesting suggestion but with the time constraints I suggest this be deferred to a separate report.
viii	3	This would be more correct: "Some scenarios of future CO2 emissions overestimate observed levels" Sentence has been removed
viii	5	This would be more correct: Some detailed climate models run "hot" in their simulation of the climate of the past few decades, while many have underestimated the amount of surface warming. More research is needed to select the most skillful and reliable models. The need for more research on model development is implicit. Again, this would be a good topic for a separate report.
viii	6	Need reference for: "Claims of increased frequency or intensity of hurricanes, tornadoes, floods, and droughts are not supported by historical data." More research is needed to identify how frequency and intensity of weather events are affected by environmental conditions. The ES statements are all supported by the document chapters but suggest we add references to specific sections.
4ff		It is misleading to separate the photo-chemical effects of CO2 from the temperature effects. Extreme heat is hard on plants, causing them to lose water, close stomata, etc. It depends on the plant and the degree of heat. More research is needed to understand how the temperature (mean and variability) affects plant productivity and resilience. 1st paragraph of Section 2.1, Added sentence "Here we focus just on CO₂ fertilization; research on combined effects due to temperature and precipitation changes are discussed in Chapter 10."
7		Again it is misleading to separate the CO2 and the temperature effects on the oceans. The warming surface waters is having significant impact on ocean fish and habitats due to the overall increase in global temperatures This section is specifically on changing alkalinity. We haven't included a review of temperature effects on fish populations: it is one of the impacts topics we were not able to survey.
14	4	More accurate to say "because their effect remain largely unknown". Good examples include natural aerosols (sea salt, dust, biogenic aerosols). Are there others to mention? More research is needed to understand radiative effects of both natural and anthropogenic sources of radiative variability throughout the atmospheric column. Sentence added: "Natural sources of global energy imbalance other than volcanoes and total solar irradiance (TSI) are not included in these graphs because their effects remain largely unknown."
17	figure	What scenarios are the models using in this figure? SRES, as stated in text, also others including Hansen A,B,C and others as described in the Hausfather et al. paper.
19		Vegetation is only one way that CO2 is accommodated by land processes, the other is through soils and microbial processes Microbial dynamics is complex and challenging to understand but may also be a way to boost CO2 absorption by soils (which also enriches the soil nutrients!). More research is needed to better understand how plants and soil systems remove CO2 from the atmosphere.

		Noted.
19	5	More research is needed to improve the understanding and representation of land systems, carbon and nutrient fluxes in models. Noted.
20		Carbon uptake by oceans and ocean ecosystems is less well studied and modeled. The lack of spread of carbon in ocean models may result from insufficient information, ocean biogeochemistry, ecosystems and model development. More research is needed to study and model carbon, nutrient and ecosystem processes and dynamics in ocean models. Noted.
		More research is needed to map warming trends in urban, non-urban and other environments and to ensure accurate representation of regional and global trends in temperature. Noted.
27	2	"This practice" - need to clarify whether this refers to "emergent property" or discarding. I believe the authors mean the latter, but it should be made more clear Sentence rewritten: "Parameter tuning to yield an ECS target was commonplace for the models used in AR4; modelers have moved away from this practice with time."
27	3	"assumed positive cloud feedback" - this is an emergent property too, based on simulation/observation. Should be rephrased to not use the word "assumed". Further research is needed to better understand and model how clouds change with temperature and what the feedback effects are on the radiative balance. Need to clarify if cloud feedbacks are assumed, imposed or both? Can be handled editorially by deciding whether to delete "assumed" or not; deleting it allows it to remain as an implicit modifier.
		Further research is needed to narrow the uncertainty on climate sensitivity, both using models and observations. Noted.
33		The text and figure refer to 33 models, which would include the best and worst. How much does the uncertainty/range change for a subset of best-performing models? The modeling community doesn't have a leaderboard of best-to-worst models. Some of the "prestige" models from the US and UK have very high sensitivities, but they are preferred by many users for particular applications.
34	figure	How many models are included in each case? High ECS 14, Medium ECS 11, Low ECS 13. Added to Figure caption.
36	figure 5.4	How are the lower and mid-troposphere defined? Standard definitions in the paper: LT surface to ~9km, MT surface to ~15 km. Added in the Fig caption.
37	4	"excess amplification" - amplification of what? And Figure 5.6 shows tropics, is this bias only tropical? Sentence changed: "Another important model-observational discrepancy is the excess amplification or warming with altitude..." The bias is only observed in the tropics but the amplification pattern is only predicted in the tropics. Also bear in mind the tropics is nearly half the atmosphere and is where most solar energy enters the climate system.

38		Further research is needed to improve how models represent clouds and dynamics; additional observations are also needed to improve these representations. Noted.
42		Further research is needed to improve how models represent planetary albedo to align with observations. Noted.
		The greater concern with hurricanes is the amount of moisture they carry and drop after landfall, i.e. flooding. While this is an active area of research, it is worth noting that this may be the bigger issue for hurricane change with warming This is covered in the AR6 assessment as quoted, as it's one of the intensity metrics. Currently too little data to assess for trends.
56-57		The concern for many are the extreme hot temperatures without night-time cooling that provides an opportunity for recovery. This section doesn't address this. In this regards, the focus on the difference between extreme hot and extreme cold is misleading when generalizing about decrease in extremes (figure 6.3.4) - the decrease is because we don't have as much extreme cold. This metric is covered by the data in Sct 6.3.3.
60		Combining heat and humidity as a measure of extreme heat is not unusual since it is this combination that is most impactful to human health - the body cannot cool if the humidity and heat are both high. Since a warmer atmosphere holds more moisture, and CO2 causes heat (and therefore moisture) to increase, this combination is a relevant assessment of the effects of CO2 on extreme conditions that make it difficult for people. Also combining with urban regions is helpful since that is where most people live. These points are not made in the report and are important. <u>Sentence</u> be changed to read: "Given the heatwave definition and urban focus, while these increasing values since 1960 point to a growing human impact they are not informative about long term trends or..." Added sentence at end of paragraph (Irrespective of the ultimate cause of regional trends, heatwaves have important effects on society which must be addressed, as we discuss in Chapter 10.) this should address reviewer concerns.
		Patterns and variability of precipitation are poorly understood and models are particularly challenged to represent and predict precipitation, further research in this area is needed Noted.
		The authors rightly describe the extreme uncertainty regarding sea level rise. It would be helpful to add some information about the complex, highly nonlinear and uncertain processes involved with ice-sheet dynamics and ice-sheet - ocean interactions that are especially key for Antarctica. More research is needed to study and model ice sheet dynamics and ice-sheet ocean interactions. Noted. Canvassing ice sheet and ocean dynamics in that much detail beyond our scope but would belong in a separate report.
84	3	Further research is needed on climate variability, effects of ocean circulation, solar variability, model simulation of variability and statistical methods. Noted.
87-88		Anthropogenic aerosol effects may also influence the inflections in temperature in ways that are challenging to account for Noted.
91	2 and 3	Reductions in aerosol indirect (cloud brightening) effects may also explain the reduced planetary albedo, not just from ships but from reduced fossil fuel aerosols coming from the continents, China and east asia especially. This paper describes the reduction in aerosols https://www.nature.com/articles/s41612-023-00488-y This is another area that needs further research! Noted.

94	table 8.1	What are the numbers in the 3rd column? Please include in the caption. Good point. Added to caption: “Numbers refer to footnotes in original source that specify locations or region-specific confidence levels.”
95	2	I don't see an inconsistency between what Ch 11 and Ch 8 say. The first is about precipitation, droughts, tropical cyclones, heat - overall. The 2nd (ch 8) is about specific types of events in specific regions. Suggest to soften the statement about the contrasting assertions. Sentences at issue are “Evidence of observed changes in extremes and their attribution to human influence (including greenhouse gas and aerosol emissions and land-use changes) has strengthened since AR5, in particular for extreme precipitation, droughts, tropical cyclones and compound extremes” versus “No evidence of emergence in the historical period of a change in river floods, heavy precipitation, drought, fire weather, severe wind storms, and tropical cyclones”. It seems apparent to me that these statements are in conflict.
		The science of attribution of extreme events is challenging and computationally expensive; this is an area where further research is needed with potential to use AI to improve statistics Noted. Not sure about the computationally intensive point: many just run univariate GEV models and overinterpret the results. AI won't fix the bad methodology.
104		This section seems to gloss over many key points. Certainly there are limits where extreme heat and drought (water is key) could be detrimental to crops. It also depends on which crops. There is extensive literature on how certain crop viability is shifting. So a region with particular crop experience and cultivation may no longer be able to sustain that agriculture. There is cost to shifting crops across regions and farmers that needs to be accounted for. And water is key - is there enough water in various regions for energy (power plants need water) as well as agriculture when conditions are very hot for sustained periods? The comment seems to be about the validity of the underlying literature rather than our summary of it. The econometric lit tries to synthesize patterns over large areas to get at overall trends, rather than the agronomy focus on specific sites and crops.
111		Severe weather continues to disproportionately impact lower income communities as well as business that requires outdoor exposure. A thorough analysis would need to include these points and I recommend adding this caveat to the section. This is specifically addressed in Section 10.3.2
		Related to my previous comment, deaths due to extreme heat conditions appear to be increasing, particularly for certain populations and for those with underlying health conditions (which can be hard to detangle when attributing mortality). For example https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2792389 Again this topic is specifically addressed in Section 10.3.2
114		An additional concern is if the grid fails under either extreme heat demands or cold/severe-storm events, the impact on communities will not be uniform and depends on grid infrastructure which can be better in more affluent communities Good point. We don't discuss what makes for grid stability versus instability, especially in the context of many jurisdictions closing reliable power plants and opting for intermittent renewables, but the correlation between extreme weather and the likelihood of power failure is an important topic.
		The impacts of sea level rise and coastal inundation on coastal communities and in low-lying countries should be addressed. This will have impacts particularly on certain countries/regions but also on world economics Good point. The topic is germane but runs into the limits of what we can cover in our limited time. To some extent it is covered in the economics chapter since IAM damage functions include effects of sea level rise on coastal areas.
		Research is needed to better understood the likelihood and impacts of various tipping points, including changes to ocean circulation patterns, ice sheet acceleration, sea-ice loss, die-off of tropical forests, thawing of permafrost, etc. Noted. Hopefully our discussion clarifies the different types of “tipping point” topics.

		Do the authors think it worthwhile for private or public research, such as at DOE, to seek breakthrough technology that might effectively remove massive amounts of CO2 from the atmosphere? No comment
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Chapter Number	Page Number	Approximate Paragraph Number	Comment or Suggested Edit
	i		In general, criticism and re-analysis of past research is always welcome. This report summarizes some substantial concerns from a small group of researchers. The report should be reframed to reflect this and I provide some suggestions in a later comment. I suspect that simply publishing this report will not offset the hundreds of reports and publications on CO2 and Climate that have come before it. But, new analyses and communication within and outside the research community could make a positive difference, should the findings in this report be substantiated. The DOE Office of Science BER could be provided an opportunity to address the research uncertainties in this document in a thorough and robust manner. Noted.
	iii	1	As someone who used to read the DOE reports on CO2 as a graduate student in the 1990s and then conducted numerous analyses of carbon on many topic areas which were later confirmed by numerous other analyses, it seems somewhat cavalier for DOE to issue one brief conclusive report on the "impacts of carbon dioxide emissions". I suggest the following option: Change the title to "Topics of Uncertainty on the Impacts of Carbon Dioxide Emissions on the U.S. Climate" or " An Assessment of CO2 Impacts on Climate to Guide Future Research ", and then use this report to drive research/analyses for each report chapter which would conclude in separate topical reports that could be finished within a year or two. In doing so, the DOE would positively contribute to addressing some of these standing issues and hopefully enable the nation to move forward in a more productive manner. Noted. New title: "A Critical Assessment of the Impacts of Carbon Dioxide Emissions on U.S. Climate."
	vii	Forward	I appreciate the perspective. It could be useful to add or edit the Secretary's Forward to indicate that "the report has been purposefully commissioned to researchers with alternative perspectives in an effort to address these perspectives and provide some closure for the American public, the US Economy, and US energy policy." I suggest this, because it will be very obvious that a handful of skeptics were chosen out of literally hundreds of extremely active and well-respected scientist. Addressing that upfront will immediately reduce criticism, and hopefully generate a positive environment to address these issues. Everyone would like to see convergence of findings on these issues. Noted. The suggested sentence is not well-phrased, but the reviewer is correct that everyone will see the names and know that the document is coming from a particular perspective. The problem is no such concerns were expressed when people with known biases got put in charge of NCA or IPCC chapters. The path to convergence starts with the wider community admitting that they've been keeping a lid on the necessary discussions. We do not have any control over the Secretary's Foreword
	viii	2	Any increase in greening from additional CO2 will likely be more than offset by longer growing seasons with higher temperatures (i.e., more days over 100). This causes serious risk to the US midwestern "bread basket", which is why this has been considered a national security concern. The data supporting this trend has been published a few times now in Science by a fellow out of Stanford, among others. Sources: Lobell and Field. 2007, doi: 10.1088/1748-9326/2/1/014002; also Sloat et al. 2020, doi:10.1038/s41467-020-15076-4 has a thorough introduction with many citations. The effects, including compound effects, on Agriculture are addressed in Ch 9

	viii	3	My understanding is that the upper bound of emissions (i.e., very high) is business as usual, with no mitigation, and a high-end of growth. It's a worst, yet plausible, case scenario. Similarly, the lowest emissions (i.e., very low) scenario includes technologies that don't yet exist including significant CO2 removal. Both are there to understand plausible extremes. The more likely scenarios are the low to high scenarios. I'm sure researchers are open to revisiting how things are bounded and presented if there are reasonable objections. It seems that within the expert community people are quick to set RCP8.5 aside as a fringe scenario. The problem is it dominates the impacts literature and the media coverage thereof. So the critical discussion herein is needed.
	viii	4	This may be true. But data driven analyses may not capture anticipated feedbacks. They attempt to by design. Limited by data especially ocean heat content, but they take it into account.
	viii	6	I am a big fan of data and meta-analysis. However, I'll note that I do not think forest management practices are overlooked. In fact, it is one of the main driving story lines (i.e., too much fuelwood exists, so we need to harvest more forest). There remains strong debate on the efficacy of fuelwood removal over large areas as an effective means of wildfire reduction. The key to this analysis is to look at whether the extent (not the numbers) of fires has grown and whether the burned areas are returning to forests or returning to brush or grassland. If it's the latter, then that is more likely due to regional changes in climate (temp and precipitation). Again the issue may be what experts discuss among themselves versus what's out there publicly.
	viii	8	I think we can point to sea-level rise in south florida, crop damage, and disease vectors fairly easily. I'm not aware of what costs are associated with these 3 items, but I suspect it's quite large. Dealt with in Ch 11 on economic costs and the SCC.
	viii	9	Yes, this is an important paragraph. Most scientists are not activists. Just because there is a science finding, scientists don't expect that to turn into policy. The public and the democratic system can determine the policy using an evidence-based risk/benefit analysis, just as noted here. Opening up this conversation (which should have been done decades ago) would be welcome and would better engage the public on this issue. DOE could in fact take a leading role here and help address a major national issue. A point of sincere agreement.
1	2		This is all generally correct. I would like to think this is common knowledge. Yes but bears repetition
2	4	1	Why use studies based on satellite sensors? I'm quite sure there are studies (again, out of Stanford) that use historic yield data (county-scale USDA data and global FAO data) with associated temperature and precipitation data. Those analyses do not agree with your findings here, I think. But, we can certainly pose these questions to our scientists that study and develop land models and develop a report based on all available data. I'll also note that for sometime data synthesis wasn't considered fundamental science and was therefore largely ignored. Enabling the researchers to conduct robust data analyses on this and other topics would be largely welcomed. See Ch 9 on Ag effects for the studies on yield data.
2	5	Figure 2.2	All data is interesting and useful for perspective and understanding. But isn't the main question whether we are driving up CO2 and temp at a rapid pace in the post-industrial era? This graph does not help answer that question. Figure 2.2 has been deleted.

2	7	3	Stating that increased aridity in drylands will not lead to decreased productivity seems a bit questionable. We can point to precipitation gradients from high to low precipitation that supports forests to grasslands to shrublands, respectively. Less water in general will mean less productivity; this can be seen in different forest compositions as well. The authors cite Zhang et al. (2014), but Zhang's main point is that the direct CO2 effect may be causing greening in drylands that offsets the decreased precipitation. This may be more specific to dryland vegetation, and Zhang et al. specifically state that this finding is relevant to north-east Brazil, Namibia, western Sahel, Horn of Africa, and central Asia. Zhang 2024, not 2014. The point here is to explain benefits of higher CO2 in terms of crop water productivity. Zhang acknowledges increase in desertification (as we note) but points to a global pattern of greening in arid areas.
2	9	3	I do not disagree with this observation of a decline effect, and I have seen it in some of the early biomass energy analyses that appeared in prominent journals and were then corrected over a few years. While it is unfortunate that some try to grab headlines with unsupported assumptions, it does seem that other researchers tend to provide counter arguments and analyses fairly quickly, indicating that the system does in fact work fairly well. Yes, part of the problem is the later counter-evidence gets relatively little attention, hence this report.
3	19	last	Yes, CO2 uptake by land processes have uncertainty associated with them. It's worth noting that DOE researchers (many of whom are retired now) were world-leading and making progress in this area, but nearly all work on CO2 uptake and emissions stopped 10-15 years ago due to political pressure and political concerns. The Carbon Dioxide Information and Analysis Center at ORNL, now cancelled, was a main contributor to the Global Carbon Project. Now the US is woefully behind and ceding expertise on this to the Europeans (as cited in this report). We are also ceding expertise on carbon monitoring via satellites to other countries. There's nothing necessarily wrong with this if this is where the US wants to go, but it's important to recognize that we have lost significant capacity due to policy changes over many years. We specifically recommend the government increase its focus on basic climate monitoring and data dissemination. The CDIAC was very valuable and we lament its closure.
5	44	1	Some of the early work on this topic was done by researchers at Stanford. But there are plenty of other papers. Here's one that came up in a quick search: https://www.pnas.org/doi/10.1073/pnas.0906865106 We discuss this paper in Ch 9.
5	44	1	Contradicting a number of large meta-analyses on the topic of decreased yields with increased temperature is ok. That's what science is all about. But it's going to have to be done in a more robust way than a couple paragraphs here with one or two citations. This section concerns temperature trends in the corn belt; the discussion of yields is in Ch 9.
6	47	chapter summary	This is very important. I have not dug into the data on extreme storm data (both numbers and intensity). Getting researchers together that disagree on a topic, analyze the data, and publish findings together can be very productive. DOE could sponsor a workshop and bring together a broad range of experts and find answers to extreme weather trends. Good idea

6	47	chapter summary	I conducted some analyses on wildfire years ago. I saw the bias in the university textbooks and in the wildfire working groups, who essentially went by textbook teachings. It was rare that people went back to the original data. The last time I checked the actual data (a good 10 years ago), I found that...you're correct...the number of fires had not changed much. What does seem to be changing is that the extent of fires has grown, and this is mostly attributable to hotter and drier conditions. I do not believe there is more fuel load now than there was before the US was settled. Arguing that harvesting will decrease fire is nonsensical; you have no idea where the lightning is going to strike and subsidizing the thinning of all forest in the western fire zone would be cost prohibitive. I think we need to stop using wildfire management as a justification for harvesting. If we want to harvest more, than do it, and stop using fuel load arguments (which is more of a concept than proven reality) as a reason to do it. The biggest issue here is encroachment of housing communities into the Wild-Urban Interface (WUI) and how we want to handle that with policies. Fire is really only bad if it's burning someone's house down. Otherwise, it's a natural progression in forest dynamics. Sources: Campbell et al. 2012. doi:10.1890/110057.; Schoennagel and Nelson. 2011. doi:10.1890/090199. Excellent comments. It's a big topic we can only glance at but we are trying just to get some pertinent data into the discussion.
6	57	6.3.2	The NCA5 is cited here and elsewhere. However, the USGCRP website that hosts the NCA reports has been removed. Hence, there is no way to read and review the referenced findings. This DOE report is therefore arguing against something that no longer exists, and that may appear questionable. Noted. Out of our control.
7	74	2	Given the satellite observed ice sheet dynamics, I'm not sure that ice sheet retreat is that hypothetical. Our reference is to hypothetical instabilities, i.e. massive disintegration.
7	all		This is the first time I have seen all sea-level rise estimates discredited by an offset from land subsidence. This is certainly a global dynamic that we would want to capture and understand in Earth system models, and DOE can look into this further with analyses and experiments if necessary. Noted.
8	86	all	This and other chapters cite the IPCC AR6. The IPCC provides a global process to address the issues and uncertainties in this report. Perhaps this report can set a path for pivoting research and re-engaging in a useful manner. That's a big ask.
9	104	chapter summary	The last sentence in this summary is not necessarily accurate. The authors cite Ainsworth and Long (2020) with respect to increased CO2 effects on crops. But, Ainsworth and Long (2020) indicate that increased temp and decreased precipitation will have negative impacts on crops, while increased CO2 may offset some of those negative effects. It is the impact of CO2 on climate and the subsequent impact on crops that is the concern; not the direct effect of CO2 on crops. Re written: "U.S. agriculture appears to be robust to current and expected CO2-induced warming."

Chapter Number	Page Number	Approximate Paragraph Number	Comment or Suggested Edit
2	3	2.1.1, para. 2	Zheng not in reference list. Do you mean Zeng? Yes, fixed.
2	3	2.1.1, para. 3	"nearly double"? Why exaggerate? - it's a 76% increase. And they reported that future increase in GPP in extra-tropical northern hemisphere (e.g., U.S.) for [CO2] from 300 to 600 ppm of 42%, or 32% more than previous predictions (not 76%). Replace "nearly double" with "much larger than"
2	3	2.1.1, para.1	Zhu also explained that "other factors (OF) not considered in models, such as forest management, grazing, changes in cultivation practices and varieties, irrigation and disturbances such as storms and insect attacks, can be a cause of mismatch between observed and simulated LAI trends.... OF contributes the most to the observed LAI trend over 25.0% (increase) and 5.3% (decrease) of the vegetated area" We don't claim CO2 is the only factor.
2	3	2.1.1, para.2	This report is meant to focus on the U.S., so it would be more appropriate to discuss greening trends in the U.S. Fig. 2.1 shows that the trend in LAI across much of the U.S., with the exception of the Southeast, is less than the global average. Negative OF effects are mainly found in northern high latitudes (e.g., Alaska). Growing season warmth is the dominant factor in cold regions (10.1038/s41558-018-0258-y). Significant browning also is occurring in parts of Alaska (10.1175/EI-D-20-0025.1) But the effect is still positive. In Ch 9 we discuss US-specific evidence concerning CO2 and crop yields.
2	3	2.1.1, para.2	Greening of the Arctic can have important adverse consequences. Direct observations support that warming and increased vegetation cover in the Boreal-Arctic region showed a "robust increasing trend of CH4 emissions (+8.9%) with strong inter-annual variability. The majority of emission increases occurred in early summer (June and July) and were mainly driven by warming (52.3%) and ecosystem productivity (40.7%)." Yuan et al 2024 (10.1038/s41558-024-01933-3). We don't claim it's good or bad, only that it's been observed.
2	3	2.1.1, para.3	Wang et al 2020 (10.1126/science.abb7772) report a decline over recent decades in CO2 effects on global photosynthesis, possibly due to increasing nutrient interactions or interactions with effects on LAI. It's a controversial finding that attracted skeptical comments in <i>Science</i> regarding the validity of the satellite data and the statistical methods used https://www.science.org/doi/10.1126/science.abg2947 https://www.science.org/doi/10.1126/science.abg4420 https://www.science.org/doi/10.1126/science.abg5673 While the authors in reply defend the satellite data, they acknowledge they may not have dealt adequately with confounding non-CO2 factors. So, it seems premature to invoke this result.

2	4	2.1.2	Much of this information in this section is appropriately covered in chapter 9 on agriculture. Chapter 2 purports to have a wider focus (global and environment responses), so it should not dwell on responses of individual crop plants (crops account for only 15% of global GPP). There has been plenty written on ecosystem response to eCO₂, but evidence such as Fig. 2.3 is not relevant. All analyses of direct eCO₂ effects reveal an overriding interaction with other environmental factors (nitrogen and temperature), and global models show that eCO₂ only partially compensates for the negative effects of climate change on ecosystem carbon response. We struggled with how to divide material up in Ch 2 and Ch 9. The solution we came up with was that here we are addressing direct CO₂ effects, namely CO₂ fertilization; later we discuss Ag effects in more detail. Not everyone paid attention in high school biology. Figure 2.3 serves as an illustration of a point that non-specialists are often surprised to learn, namely that CO₂ is plant food.
2	4	2.1.1, last para.	Zhang, 2025 (10.1016/j.ecolind.2025.113762) reported that although vegetation cover was increasing, resilience against external disturbances (drought, heatwaves, wildfires) has simultaneously declined. They use the lag-1 autocorrelation coefficient as the measure of resilience based on Critical Slowing Down theory. The results are suggestive but very noisy and require a lot of assumptions to equate to a loss of ecosystem resilience. Since the authors also show that vegetation cover is increasing at the same time the results don't appear strong enough to merit any change in our discussion.
2	7	2.1.3, para. 2	Cheng did NOT report "increased plant growth"; they reported increased GPP. The distinction is fundamentally important, has been recognized for decades, and is completely ignored in this chapter. Cheng et al. did refer to an increase in Net Primary Production as well, but you are correct they focused on Gross Primary Production. Sentence rephrased "Similarly, Cheng <i>et al.</i> (2017) noted that increased Gross Primary Production from 1982 to 2011 due to rising..." and GPP be added to the Glossary. More generally since GPP and NPP are closely correlated the use of "plant growth" is suitable.
2	6-7	2.1.3	This material is repeated in chapter 9 where it belongs. Here, it would be more appropriate to focus on how eCO₂ interacts with drought on ecosystem response (e.g., 10.3390/atmos12020212) We tried to avoid repetition but there is some. We discuss drought in Ch 8: since we don't see global and US trends, the issue of declining CO₂ fertilization during droughts isn't a key issue at this point.
3	19	3.2.2, last para.	Regarding the uncertainty in the land sink, a primary reason for this uncertainty is that the primary response of photosynthesis to CO₂ does not predict C sequestration because of strong interactions between CO₂ and climate, nutrients, stand dynamics, and other factors. That is why the almost complete focus in this report on crop plants and plant responses in greenhouses does not inform us about "CO₂ uptake by land processes" We aren't making any strong claims about the land sink, we only report the results in the Global Carbon Project. Not sure if the reviewer is challenging them or not.
9	104	all	This chapter is silent on agricultural effects on atmosphere and climate. Sokal and Kachel 2025 (10.3390/en18092272) conclude: "The current study demonstrated that agricultural activities significantly contribute to the emissions of three main greenhouse gases: carbon dioxide, nitrous oxide, and methane." Emissions from the Ag sector are included in the IAM results discussed in Ch 11.

9	105	9.2, para. 2	The section title is "Field studies..." but the next three paragraphs are primarily about responses of potted plants in growth chambers or greenhouses (with exception of Blandino, which was a field study and showed a much smaller response than the pot studies). There is an important reason that the field data cited in Blandino and in SoyFACE show a smaller response than data from the potted plants under artificial conditions. These data are barely relevant to the topic you are trying to address. FACE plot studies are field studies, and we also discuss other field studies. However we also include some lab experiments. <u>Heading changed to "Field and laboratory studies of CO2 enrichment."</u>
9	105	9.2, para. 3, 4, 5	CO2Science.org website is a highly biased and unreliable website. They report on papers, or specific sentences in papers, that support their view and ignore conflicting reports or qualifying sentences. If there was another site that gathered that much data, we'd cite it. We'd need some evidence of actual bias to disqualify the CO2Science.org archive given the extent of its coverage.
9	105	9.2, para. 3	This is a report for the US. Why are you citing soybean studies in China when there is a major soyFACE study in Illinois? Yield in SoyFACE increased in eCO2 but declined with increasing temperature (10.1093/jxb/erac503). eCO2 did not result in water savings as hypothesized but rather increased soil moisture depletion. (10.1098/rstb.2024.0230) The Chinese study is on point regarding CO2 enrichment. The first study referenced by the reviewer (10.1093/jxb/erac503) only subjected soybean to elevated temperature without varying CO2, so it isn't relevant to our discussion. The second reference is to a general literature survey which doesn't appear to say anything different from what our chapter says.
9	106	9.2, para. 2	Ainsworth et al, 2025 (10.1093/jxb/erac503) state: "Early season stimulation in biomass at elevated [CO2] more than offset lower stomatal conductance in crops, resulting in greater depletion of soil moisture, instead of water savings [30,31]. Wheat tiller survival and grain filling was also reduced by elevated [CO2] under dry conditions [32]. The CO2 fertilization effect was also significantly reduced by growth at elevated temperatures in FACE experiments, again suggesting that high atmospheric [CO2] may not offset the negative impacts of global warming [29]. Thus, it may be that, to date, elevated [CO2] and the resultant climate changes have had net positive effects on agroecosystem productivity, but as climate change intensifies, there will be a shift towards net negative effects as has been suggested for natural ecosystems [3]." Our summary statement on the Ainsworth review is accurate regarding the CO2 effect. They raise the question of compound effects from simultaneous changes in CO2 and temperature. That topic is taken up in the discussion of the NBER study and Section 9.3

9	107	1st para.	Another study that should be cited is Hultgren et al, 2025 (10.1038/s41586-025-09085-w). "For all crops except rice, we estimate that warming will likely reduce global yields by 2050 (probability of loss ranges from 0.701 (sorghum) to 0.946 (wheat)... " "We estimate that global production declines 5.5×10^{14} kcal annually per 1 °C global mean surface temperature (GMST) rise (120 kcal per person per day or 4.4% of recommended consumption per 1 °C; $P < 0.001$). We project that adaptation and income growth alleviate 23% of global losses in 2050 and 34% at the end of the century (6% and 12%, respectively; moderate-emissions scenario), but substantial residual losses remain for all staples except rice." Regions with moderate average temperatures tend to suffer the largest yield losses. "Adjusting for CO2 fertilization does not qualitatively alter the structure of our findings ... but it does reduce the central estimate for end-of-century yield losses by 5.0– 9.5 percentage points... and increases the likelihood of positive aggregate effects." The Hultgren study came out after our draft had been complete. The headline results which generated massive publicity were based on RCP8.5 with no CO2 fertilization. One of our other reviewers wondered why we focused so much on the deficiencies of RCP8.5 when everyone knows it's a marginal case – this study is a good illustration of why. Fig 3 in Hultgren
9	108	1st	Reference to Ziska paper greatly mischaracterizes it. Ziska clearly indicates an effect of eCO2 on nutritional quality, but he indicates there is uncertainty in some of the mechanisms behind that response, including the simple dilution hypothesis. He states up front: "However, it is the direct effect of rising [CO2] on plant chemistry and stoichiometry that represents a continuing threat to the nutritional integrity of both human and animal systems." Ziska doesn't dismiss CO2, but he points out that nutrient dilution has also been observed under historical conditions in which CO2 was likely not the driver. Sentence rephrased "as is the evidence that nutrient dilution observed to date is entirely attributable to higher CO₂"
9	108	9.4, para. 1	Evidence for nutritional decline under eCO2 is widespread: Toreti et al, 2020 10.1038/s43016-020-00195-4) "A meta-analysis of 228 pairs of experimental observations on barley, potato, rice and wheat reported reductions in protein concentrations ranging on average from –15.3% to –9.8% under eCO2, while the reduction was relatively small (–1.4%) in soybean." AND Ainsworth et al 2025: "The positive 'CO2 fertilization' effect on crop yield is complicated by a decrease in many nutrients in elevated [CO2]. An analysis of 130 varieties of plants found that elevated [CO2] decreased the concentration of 25 important minerals by 8% on average, and the carbohydrate to mineral ratio was increased in these plants." We don't dispute any of this; it corresponds with what we say.
9	109		URL for Taylor and Schlenker paper is incorrect. It should be https://www.nber.org/papers/w29320. "papers" not "paper. Was this report peer reviewed? I cannot find it in a peer-reviewed journal. Thanks for the correction. I don't think it has appeared in print anywhere other than the NBER series.

12	129	This chapter is highly distressing, but I suppose it encapsulates the whole thesis of the document. Apparently, there is no point in policies to reduce emissions (or make the necessary changes in energy policy to accomplish emission reductions) because it will make no difference to the atmospheric CO2 concentration or climate. So why bother? Would you have said this in 1970 (CO2= 326), 1990 (CO2 = 354 ppm), or 2010 (CO2=390)? Probably so. And in 30 years when CO2 is 500 ppm, will it be fair to look back and evaluate your apparent call for inaction in the statement here "And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate." But I suppose this attitude is justified if there is no adverse consequence and the only important effect of rising CO2 is to make little plants in greenhouse grow bigger (e.g., Fig. 2.3), and indirect effects on heat stress, drought, fires, sea level, etc. aren't worth discussing. Points taken but the reviewer is calling attention to actual problems finding mitigation strategies with positive net benefits.
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Ch	Page	para	Comment or Suggested Edit
1	2	full text	This chapter points out that the primary concern around human emissions of CO2 is that it changes the radiative balance of the atmosphere. The chapter also makes the points that CO2 has no toxicological effects on humans at current atmospheric levels, and that CO2 is necessary for photosynthesis, with the potential to stimulate plant growth at higher concentrations. These points are well-established scientific facts. Yes and experts know them but non-experts aren't necessarily aware of them.
2	3	3	It would be more reflective of the literature to say here that "Many studies over the past decade have confirmed a global greening pattern (increase in LAI) attributable to rising CO2 levels, changes in climate, changes in nitrogen deposition, land cover change, and other factors." We have added "in part" to sentence.
2	3	3	While the Zhu et al. 2016 study did find that 70.1% (+/- 29.4%) of the integrated global change in LAI was attributable to changes in CO2, most of the observed change in LAI is concentrated in the tropical forest regions of South America, Africa, and Indonesia, as shown in this report's Figure 2.1, reproduced from Zhu et al. In terms of the fraction of global land area influenced most by the factors considered in Zhu et al. 2016, effects on LAI from changing climate is the dominant factor (positive effects for 28.4% of land area plus negative effects on 4.7%, for a total area with dominant climate influence of 33.1%), followed by other factors not represented explicitly in the study or in the models (positive effects on LAI from other factors over 25.0% of land area plus negative effects over 5.3%, for a total area with other factors as the dominant effect of 30.3%), and then CO2 effects (23.2% of land area dominated by positive effects and 0.1% with negative effects, for a total of 23.4%). Since the report is focused on the U.S. it would be helpful to indicate the global context for the numbers reported. We have added new text "Other contributors included land-use changes, warming and nitrogen. The fraction attributable to CO2 was largest in the tropics; other factors played more dominant roles in CONUS."
2	3	3	The dominant factors related to changes in LAI over the U.S. (including Alaska) are land cover change (+LCC), climate effects (+CLI), other factors (+OF and -OF), and then CO2 (+CO2). There are more extensive regions where +CO2 is the dominant factor for the boreal forest zone in Canada. Given that, and given the explicit focus of the report on the U.S., it would be useful to call out in this section that the global greening pattern has distinct geographic variation in driving factors, and that over the target geography of the U.S. it seems to be dominated by factors other than increasing CO2. See my powerpoint slide 1 for a zoom on the area of interest from the Zhu et al. 2016 paper. Addressed with new sentence: CO2 fertilization effects are influenced by local temperature and nutrient and water availability, all of which vary regionally.
2	3	4	"Zheng et al. (2017) confirmed the pattern..." should be modified to say "Zhen et al. (2017) confirmed the pattern of observed greening..." As written, and in the context of the previous paragraph, the current text suggests that Zheng et al. 2017 confirmed the pattern of greening being related mainly to increased CO2, a factor which was not examined in their study. Changed: confirmed the pattern of greening, noting that over thirty years it had added 8 percent...
2	3	4	Without the addition of the appropriate context in the preceding paragraph (my notes 3, 4, and 5) the remainder of this paragraph could be misinterpreted to mean that the impacts of greening on air temperature are attributable back to a positive effect of CO2 on greening. Rewording has addressed this.

2	3	4	The sentence "Greening has been observed globally but Chen et al. (2019) noted that China and India were exploiting it through land management changes" is misleading. Chen et al. (2019) shows that China and India are <i>causing</i> the observed greening in large areas by intentionally increasing the land area occupied by forests (China) and increases in harvested area in croplands, mainly due to multi-cropping, heavy fertilizer use, and expanded irrigation (China and India). It would be more accurate to say "Greening has been observed globally, but Chen et al. (2019) represent a disproportionate fraction of the total greening trend, accomplished through intentional increases in forest area (China), and expansion of multi-cropping, fertilizer use, and irrigation in croplands (China and India)." Changed: "Greening has been observed globally. Chen et al. (2019) show that in China and India much of it is driven by land management changes"
2	3	3 and 4	Given the changes suggested in these two paragraphs, it raises the question of whether the section title (CO2 and global greening) is itself misleading. That title wrongly suggests that all the content to follow is reflective of a direct influence of CO2 on the observed global greening trends, when the literature presents a much more <i>nuanced</i> interpretation. The changed to CO2 as a contributor to global greening
2	3	3 and 4	It would be worth noting in this section that the multiple remote sensing-based datasets for LAI changes have remarkable differences, especially when comparing the figure 2.1 reproduced from Zhu et al. 2016 with the MODIS-based data record from Chen et al. 2019 (their figure 1). That means it is difficult to place a lot of confidence in the attribution of changes in different regions to different factors. See my powerpoint slide 2 for a comparison of the four datasets used in Zhu et al. 2016 and Chen et al. 2019. Thank you for this information. It is an interesting point but gets into more specialized detail than is necessary for this report.
2	3	5	The authorship for the Haverd et al. 2020 citation is not correct in the References section for this chapter. The correct citation is: Haverd, V., B. Smith, J. G. Canadell, M. Cuntz, S. Mikaloff-Fletcher, G. Farquhar, W. Woodgate, P. R. Briggs and C. M. Trudinger 2020. Higher than expected CO2 fertilization inferred from leaf to global observations. Global Change Biology 26(4): 2390-2402 DOI: https://doi.org/10.1111/gcb.14950. Corrected
2	3	5	A more recent and more comprehensive study (Keenan et al. 2023) reexamined multiple data constraints and concluded that the model used in Haverd et al. 2020 (CABLE) is outside the likely range of CO2 fertilization effects, with higher CO2 fertilization than indicated by multiple independent constraints. At the very least this more recent paper should be cited in the report, with text indicating that the central estimate from the TRENDY models is more likely to be in the range of observational constraints than is the CABLE result. As it stands the report suggests that the latest science indicates that most models have underestimated the fertilization effect, and the literature doesn't currently support that conclusion. See: Keenan, T. F., X. Luo, B. D. Stocker, M. G. De Kauwe, B. E. Medlyn, I. C. Prentice, N. G. Smith, C. Terrer, H. Wang, Y. Zhang and S. Zhou 2023. A constraint on historic growth in global photosynthesis due to rising CO2. Nature Climate Change 13(12): 1376-1381 DOI: 10.1038/s41558-023-01867-2. Added sentence: However Keenan et al (2023) estimated a lower fertilization rate more in line with models.

2	4	1	The attribution analysis in the Chen et al. 2024 paper is very sensitive to the choice of multiple regression vs. partial correlation (their figures 3 vs S7, respectively), and in both cases they seem to misattribute the significant increases in LAI in India and China to CO2 rather than to changes in landcover and cropping practices. This kind of regression-based attribution is less informative than the model-based inference used for example by Zhu et al. 2016. The description of sensor calibration issues in this paper is also very cursory. It would probably be better to refer to the review paper of Piao et al. 2020 to support the claim of continued greening. Piao, S., X. Wang, T. Park, C. Chen, X. Lian, Y. He, J. W. Bjerke, A. Chen, P. Ciais, H. Tømmervik, R. R. Nemani and R. B. Myneni 2020. Characteristics, drivers and feedbacks of global greening. Nature Reviews Earth & Environment 1(1): 14-27 DOI: 10.1038/s43017-019-0001-x. Thank you for the comment. We have taken out the details about the Chen et al. analysis and say simply “Piao et al. (2020) and Chen et al. (2024) report that the greening trend continues with no evidence of slowdown, and CO2 fertilization remains the dominant driver”
2	4	2	The section 2.1.2 (Photosynthesis and CO2 levels) lacks coherence. It seems to be a collection of uncontroversial points about the ability of increased CO2 concentration to stimulate plant growth and reduce water loss through stomates. Figure 2.2 seems intended to show that the current levels of CO2 are not high compared to levels experienced in Earth's deep geologic past. A balanced treatment of the topic might call out the rate of change in CO2 concentration from human-caused emissions, and how both that rate and the absolute levels diverge radically from rates of change and ranges of variability over the past hundreds, thousands, and hundreds of thousands of years. See my powerpoint slide 3 for an example set of figures that might be included. In response to another reviewer, we have added the sentence “While the modern rate of change in CO2 is likely high compared to all prior intervals, the geological evidence is that plants and animals evolved under much higher CO2 levels than at present.”
2	7	4	The report suggests that the topics of CO2 fertilization and increased water use efficiency are not adequately treated in recent IPCC reports. In IPCC's AR6 WG I report there is an entire chapter devoted to an assessment of carbon cycle processes (Chapter 5, Global Carbon and Other Biogeochemical Cycles and Feedbacks). This is precisely where one would expect to find information about CO2 fertilization and water use efficiency. In the Executive Summary for the chapter is the following bolded headline: Increases in atmospheric CO2 lead to increases in land carbon storage through CO2 fertilization of photosynthesis and increased water use efficiency (high confidence). The associated Executive Summary text includes reference to two figures, three chapter sections, and a cross-chapter box all dealing directly with this topic. The Executive Summary text also references the important topic of nutrient dynamics and their interactions with fertilization and ecosystem-climate feedbacks, a critical nuance of the interaction of CO2 and vegetation productivity that is ignored in the report reviewed here. We acknowledge that the topic is addressed in the body of IPCC reports. But we draw attention to its omission from summary documents.

2	8	2	Section 2.2.2 (Coral reef changes) has a strong focus on past examples of early investigations that are later updated. There is also a note about the difficulty of publishing negative results, with a quote that this pattern "is true across all of science". Given the objective of this report, I suggest a shift in tone away from complaints about the kinds of papers that do and don't receive media attention, and instead highlight the latest synthesis of results about the likely future of coral reefs. A relatively recent synthesis paper (Cornwall et al. 2021) in a well-respected journal (PNAS) based on collated data from 233 locations worldwide projects that 37% of reefs will stop accreting and thus fail to keep up with sea level rise by 2050 under the low emissions RCP2.6 scenario, and no reefs would be able to accrete at a rate to stay ahead of sea level rise by 2100 under either RCP4.5 or RCP8.5. This analysis finds that most of the loss of net accretion rate is due to bleaching events, and a minority of the impacts are due to "direct physiological impacts of ocean warming and acidification on calcification or bioerosion". C.E. Cornwall, S. Comeau, N.A. Kornder, C.T. Perry, R. van Hooidek, T.M. DeCarlo, M.S. Pratchett, K.D. Anderson, N. Browne, R. Carpenter, G. Diaz-Pulido, J.P. D'Olivo, S.S. Doo, J. Figueiredo, S.A.V. Fortunato, E. Kennedy, C.A. Lantz, M.T. McCulloch, M. González-Rivero, [...] & R.J. Lowe, Global declines in coral reef calcium carbonate production under ocean acidification and warming, Proc. Natl. Acad. Sci. U.S.A. 118 (21) e2015265118, https://doi.org/10.1073/pnas.2015265118 (2021). This is a model projection study whereas for the very limited purpose of this section we are focusing on current and historical observations.
3	14	1	The study by Connolly et al. 2021 uses a linear regression approach to estimate the amount of variability in surface temperature trends that could be explained by total solar irradiance time series. Their approach is to first model the temperature trend with TSI as the dependent variable, and then compare the residuals from that fit to anthropogenic forcing factors. This is an obviously biased approach, and in fact a full paper was published the following year (in the same journal) laying out the erroneous methods and the faulty conclusions they produce (Richardson and Benestad 2022). Richardson, M. T. and R. E. Benestad 2022. Erroneous use of Statistics behind Claims of a Major Solar Role in Recent Warming. Research in Astronomy and Astrophysics 22(12): 125008 DOI: 10.1088/1674-4527/ac981c. While I agree with R&B that a partial regression is biased unless the regressors are orthogonal, Connolly et al. replied in 2023 at https://iopscience.iop.org/article/10.1088/1674-4527/acf18e in which they used updated AR6 data and reproduced their main result using multiple regression. However they also emphasized that it is only one of many possible results depending on choice of solar proxy and surface T record,
3	18	1	Section 3.2.2 (The carbon cycle relating emissions and concentrations). There is no new information or analysis presented in the chapter, and it relies heavily on Global Carbon Project information. Figure 3.2.3 is described as showing a seven-fold difference in the recent trend in land carbon sink estimates across land models, and this is given as a potential driver of uncertainty in future carbon cycle and climate change predictions. Variation among models is well known and is one of the reasons exercises like CMIP and GCP rely on multi-model ensembles when assessing the state of the science. The distribution of results looks fairly typical in this diagram, with a strong central value around 1.3 to 1.3. We're not claiming to have added new information, just reviewing what's out there.

12	129	3	The following sentence is misleading: "And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate." It is true that bringing global emissions immediately to zero would not reduce CO2 concentrations on short timescales. It is not true that this same scenario means no reduction in human influence on the climate. We must compare the zero emissions scenario to something, and the most meaningful comparison is the current trajectory of increasing emissions and the resulting super-linear increase in concentration. So by reducing emissions to zero we clearly avoid the expected increases in concentration and the expected increases in radiative forcing together with increased near surface air temperature and all the other expected consequences. So our change in action - going to zero emissions - does in fact have an immediate and growing human influence on the trajectory of the climate system. That is not an argument for reducing our emissions to zero tomorrow, it is just an argument for logic and clarity in how we talk about consequences of different actions. The sentence in the text is correct. It's also true to say that going to zero emissions would, over time, open up a widening gap between observed and counterfactual. But realistically we are only looking at marginal changes. The stock-flow mismatch is one reason IAMs have not recommended going to zero emissions.
12	129	5	Regarding the sentence "The practice of referring to unilateral U.S. reductions as "combatting climate change" or "taking action on climate" therefore reflects a profound misunderstanding of the scale of the issue." This makes the dubious assumption that when people refer to "combating climate change" or "taking action on climate" they are ignorant of the scale of the problem. Instead, it is probably more justifiable to assume that it is well-understood by most people who advocate for these local and national changes that the major emitters must act together to make a big difference in global emissions. It is at least worth considering, in the context of this report, that a path toward action at the necessary scale will require local and national action from a broad consortium, and that individual advocacy is a useful and necessary starting point for shifting the inertia of global policies. Sentence modified to read "The practice of referring to unilateral U.S. reductions as "combatting climate change" or "taking action on climate" on the assumption we can stop climate change therefore reflects a profound misunderstanding"

ch	pg	para	Comment or Suggested Edit
Overarching	Overarching	Overarching	• I would like to thank the authors for the opportunity to provide comment on this report. Providing decision-makers with information about the impacts of carbon dioxide emissions on the U.S. climate is critical as they face consequential decisions about the future of energy, agricultural, and environmental policy. Assessments of the science such as IPCC reports and the NCA benefit from undergoing robust review including expert review, public review, and government review with review comments and responses made publicly available. Similarly, important government reports and regulations undergo inter-agency review and are published in the Federal Register for a full notice and comment process and publish a public response to comment. While these processes are far from perfect, they offer the opportunity for improvement and help lend authority to the final products, and I highly encourage you to undertake a similar robust and open peer review process for this report to enhance the report’s credibility in the eyes of decision-makers and the public.
Executive Summary	viii	1	• There is a disconnect between the stated intent of the report by the authors in the preface, “whether carbon dioxide emissions endanger the U.S. public,” and this executive summary, as well as the organization of the report. Would suggest aligning by either reframing the focus in the preface to better match the organization of the report, or better aligning the report organization with the stated focus. Preface has been reworded and the statement eliminated. We have also changed the title to clarify this
Preface	ix	3	• “While the report is intended to be accessible to non-experts, we have omitted some introductory or explanatory material that can easily be accessed elsewhere. Nor have we attempted to survey entire literatures related to the topics covered.” • While this approach is understandable given the time constraints this report was produced under, given the level of visibility this report will have, it potentially opens up the report to criticism of being misleading by omission – focusing on areas where the authors disagree with the broader scientific literature and omitting areas large areas that are known about climate where there is less disagreement. New addition suggested above deals this; also paragraph 2.
Preface	ix	3	• “We have focused as much as possible on literature published since 2020 and referenced previous IPCC and NCA assessment reports. We have also used data through 2024 where possible.” • This is a good approach for this report; however, much of the literature cited is from pre-2020, and many of the references to IPCC and NCA reports are to older reports (e.g. NCA 4 and IPCC AR 4&5) instead of NCA 5 and IPCC reports from the 6th assessment cycle. In these sections that heavily cite this older literature, it is not clear if the newer literature does not address these points or if the issues raised in the older literature are resolved or significantly changed in the newer literature. We have included reference to previous assessment reports where the analysis is insightful and not superseded by later reports. We note that we regard NCA4 as far more credible than NCA5

Preface	ix	3	• The IPCC’s mandate is to assess the scientific literature comprehensively, including a range of views, and report disagreements. This report has a tendency to selectively quote the IPCC focusing on disagreements and excluding areas where scientists agree. This approach risks giving a misleading picture of the state of the science through omission. A possible way to address this is to have a section summarizing areas of agreement by pointing to all statements of fact and high confidence statements from IPCC AR6 before digging into the more controversial areas with disagreement. This could be a short discussion about areas of agreement up front before explaining the focus of this report on these areas of disagreement, with the IPCC statements of fact and high confidence statements included in an appendix. • The report also includes only a very small subset of the literature since 2020. The authors should describe the approach to how they selected the literature included, and if possible, point to any systematic ways excluded literature could lead to different conclusions. • It is also notable that there a fair amount of new analysis in this report done by the authors that has not yet been peer reviewed. It would be good to flag these spots with a note about why these are needed while other related peer reviewed articles are excluded. This is addressed to some extent in the revised Preface
1	2	1	• If the goal of this report is to discuss links between CO2 and climate, this is an odd way to begin the report with a focus on differences between CO2 and criteria air pollutants. It clears up a confusion of language that persists
1	2	1	• “It is an issue of concern because of its potential effects on the global climate, a complex issue that occupies much of this report.” Suggest deleting the word potential as the existence of the effect is not disputed. Deleted: “potential”
1	2	4	• “But the primary concern about CO2 is its role as a greenhouse gas (GHG) that alters the earth’s energy balance.” Would add “warming the planet” to the end of this sentence as the qualitative effect is not debated and the concern is not about the energy balance itself but about the warming effects of the imbalance. Added: “warming the planet”
2	3	1	• “The recent decline in pH is within the range of natural variability on millennial time scales. Most ocean life evolved when the oceans were mildly acidic. Decreasing pH might adversely affect corals, although the Australian Great Barrier Reef has shown considerable growth in recent years.” • Note that the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) finds that pH decline has very likely emerged from natural variability. SROCC SPM A.2.5, “Open ocean surface pH has declined by a very likely range of 0.017–0.027 pH units per decade since the late 1980s, with the decline in surface ocean pH very likely to have already emerged from background natural variability for more than 95% of the ocean surface area.” We have left this out since it relates to attribution, which is beyond the scope of what we are addressing in this chapter
3	15	3	• “Instead, the IPCC has created various sets of scenarios meant to span a plausible range of possibilities” • Suggest changing “created” to “assessed” as the scenarios are created by the science community not the IPCC. We have changed the wording to “used”
3	16	4	• “The IEA trends, which are based on plausible extrapolations of current economic and demographic trends, run below the entire envelope of RCP projections, implying not only that RCP8.5 is dubious, but that even lower emission scenarios are unlikely.” • Burgess compares IEA to the two highest SSP-RCP scenarios, not to the full range. The last sentence of the paragraph is incorrect – the range in Burgess is only no climate policies which doesn’t include the lower RCPs. The Burgess diagram is poorly-labeled and hard to understand. The text has been revised added a reference to Pielke Jr et al 2022 which has a better presentation.
3	17	2	• “As of 2023, global CO2 emissions have been tracking well below SSP7.0 and are even below SSP2-4.5.” • Note that near-term emissions are not necessarily a good predictor of long-term emissions, as the latter will depend on changes in population, demographics, technology, and policy that do not have the same influence on near-term emissions. Noted

3	22	6	• “In summary, while there is clearly warming in the land record, there is also evidence that it is biased upward by patterns of urbanization and that these biases have not been completely removed by the data processing algorithms used to produce climate data sets.” • Quantitative info would be helpful here. How large is the warming? How large might the bias be? This is a topic that needs revisiting. The quantitative estimates are 15+ years old
4	26	1	• The Chapter Summary doesn’t really capture the full tax of the chapter. Would suggest: Defining ECS/TCS, reporting values for ECS and uncertainties/methods, then reporting values for TCS, preferably with a sentence on what those values imply The terms are defined in the chapter
4	26	2	• “This raising of the lower bound is less justified; evidence since the AR6 finds the lower bound of the likely range to be around 1.8°C.” • This isn’t really discussed comprehensively in the chapter. It is discussed, in context of Nic Lewis’ research
4	26	3	• “The climate’s response to increasing concentrations of CO2 is central to the scientific debate on anthropogenic climate change” • Suggest rewording this to, “The magnitude of the climate’s response...” As currently worded it could be a bit misleading since the qualitative effect (i.e. increasing CO2 concentrations lead to increases in global average temperature) is not disputed – the uncertainty is around the magnitude of the effect. Reworded
4	26	6	• The text sites Dayaratna (2016), but this should be a reference to Dayaratna (2017) as listed in the reference section. Fixed
4	26	6	• “If ECS is very high (above 4.5°C) immediate aggressive emission controls become more imperative, whereas no CO2 emission controls are economically justifiable for ECS below 2.0°C (Dayaratna et al. 2016, 2020).” • This could use additional clarification as there are low and now carbon technologies that can be economically justified based on cost of energy alone, depending on technology, location, etc. We have left as is. We are not aware of low or new carbon technologies that are affordable and scalable. Likewise. If energy conservation pays for the low carbon tech people would have been adopting them already.

4	26	6	• “Obtaining a precise estimate is impossible, so policy making needs to account for the uncertainty.” • The Social Cost of CO2 (SC-CO2) as used by the USG in regulatory impact analyses has always accounted for uncertainties in the ECS. EPA (2016) used a probability distribution for the ECS calibrated to IPCC AR4 findings (the most recent values available at the time) to harmonize the approach for the three models used (FUND, DICE, and PAGE). EPA (2023) updated the SC-CO2 in response to NAS recommendations (NAS 2017) to include a much fuller representation of the uncertainties in both ECS and TCR, and utilized a modular approach incorporating the Finite amplitude Impulse Response (FaIR) climate model, a reduced complexity climate model, with ECS and TCR distributions calibrated to IPCC AR6 to represent this uncertainty. • The Dayaratna (2017 & 2020) papers referenced here analyze sensitivity of a subset of the older models used in EPA (2016) to just ECS estimates. It would be helpful to address the advances in the broader literature that are discussed and represented in EPA (2023) as the focus of this report is on literature published since 2020. • EPA (2016) “Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf • NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of Most of the topics are touched upon in Ch 11. The newer EPA approach (e.g. the FaIR model) don’t reflect a fundamentally different approach than before. Will discuss below.
4	28	2	• “Because of concerns about model tuning and the high sensitivity to cloud parameterizations, the IPCC AR6 (2021) did not rely on climate model simulations in their assessment of climate sensitivity, relying instead on data-driven methods.” • AR6 WGI 7.5.5 states this a little differently. IPCC’s assessment wasn’t “directly informed” but “ESMs remain essential tools.” Our statement is ok as is
4	29	3	• “For AR6, the IPCC placed primary weight on the results of Sherwood et al. (2020)...” • The IPCC assessed a large number of studies, not just Sherwood (2020). Our statement is ok as is. Sherwood et al was predominantly relied upon
5	32	1	• It would be helpful for the reader for this chapter to start with a summary figure (e.g. like IPCC AR6 WG1 – SPM.1 or Fig. 3.4). Currently, the chapter jumps right into details that will be difficult for anyone who is not a climate scientist or already versed in these issues to understand or interpret. Too late in the process to add a new figure
5	33	Figure	• “Figure 5.1 CMIP6 Average surface temperature range across 33 models and standard deviation using SSP5-85 scenario.” • SSP5-85 is an excessively high scenario that is not representative of current expectations of emissions projections. Suggest changing the figure for on with data from a less misleading and more representative scenario. The use of 8.5 doesnt make much difference given high spread for historical period, but we agree this should be changed for a subsequent version of the Report

5	34	1	• There have been extensive published comments and responses on the approach used in Scafetta (2023). Can these be reflected here? • G.A. Schmidt, G.S. Jones, and J.J. Kennedy, "Comment on "Advanced Testing of Low, Medium, and High ECS CMIP6 GCM Simulations Versus ERA5-T2m" by N. Scafetta (2022)", Geophysical Research Letters, vol. 50, 2023. http://dx.doi.org/10.1029/2022GL102530 • N. Scafetta, "Reply to "Comment on 'Advanced Testing of Low, Medium, and High ECS CMIP6 GCM Simulations Versus ERA5-T2m' by N. Scafetta (2022)" by Schmidt et al. (2023)", Geophysical Research Letters, vol. 50, 2023. http://dx.doi.org/10.1029/2023GL104960 • Z. Hausfather, K. Marvel, G.A. Schmidt, J.W. Nielsen-Gammon, and M. Zelinka, "Climate simulations: recognize the 'hot model' problem", Nature, vol. 605, pp. 26-29, 2022. http://dx.doi.org/10.1038/d41586-022-01192-2 • S. Jain, A.A. Scaife, T.G. Shepherd, C. Deser, N. Dunstone, G.A. Schmidt, K.E. Trenberth, and T. Turkington, "Importance of internal variability for climate model assessment", npj Climate and Atmospheric Science, vol. 6, 2023. http://dx.doi.org/10.1038/s41612-023-00389-0 The Schmidt et al paper is a comment on a different paper of Scafetta's and focuses on his t-statistic, which isn't pertinent to the paper we cite (from Climate Dynamics). Regarding the Jain et al paper, Scafetta uses ensemble ranges within each ECS type and doesn't simply rule models out but shows that some perform well for TAS. Relevance of the Hausfather et al paper is not clear.
5	34	4	• "Spencer (2024) has also provided a useful summary of the Model-Observation mismatch by comparing trends in surface temperature data products with those in individual climate models, as summarized in Figure 5.3; most climate models show substantially more warming than the observations since 1979." • It is worth noting that IPCC projected temperatures do not use all models and instead focus on those that best reproduce observations. So while some models may show warmer or cooler temperatures than observations, that does not imply that projections from large assessments reflect those biases. Our text speaks to the collection of CMIP6 climate models; some of those with the largest amount of warming are widely used models from the US and UK
5	37	3	• "Hence, we assess with medium confidence that CMIP5 and CMIP6 models continue to overestimate observed warming in the upper tropical troposphere over the 1979–2014 period by at least 0.1°C per decade," • "Notably, despite the accumulation of evidence of excess model warming the IPCC assigns only medium confidence to the existence of a warming bias." • This reflects a more general issue with IPCC confidence statements where the inclusion of a quantification reduces the confidence they include. Here the full statement with the quantification of 0.1C per decade is assigned medium confidence whereas a statement about the existence of the bias without a specific quantification would receive higher confidence. Noted
5	39	Figure 5.7	• Does this update with data through 2024 use the same models that Christy and McNider (2017) used, or does it use updated versions for the models as well? This would be helpful to clarify here and in other places where figures are produced with updated data. Excellent catch. Fig. 5.7 uses CMIP-6 models, this should be stated in the caption as an update of Christy and McNider with CMIP6 output. Change made
5	39	3	• "The IPCC AR6 did not assess this issue." • Was this assessed in IPCC AR5? Many of the citations here could have been assessed then. Is there any more recent evidence on these issues that should be referenced here? IPCC has never addressed this issue with rigor, but does reluctantly notes the discrepancy. I don't think AR5 assessed the amplification discrepancy except maybe to dismiss it. But AR6 should have in any case.
5	40	1	• Are there more recent papers or data available? All the info here is AR6 or pre-AR6, but more recent years have shown more surface warming. It would be interesting to show stratospheric temperatures for these more recent years as well to see how this relationship holds. Santer et al. (2025) has been added.

5	40	5	• Trends in snow cover depend on both changes in precipitation and changes in temperature. It would be helpful if these were discussed separately rather than showing the net effect for one region/season. Context for statement is that the models get it wrong
6	47	1	• This chapter relies solely on observations and does not include other lines of evidence, it would be helpful to discuss what these other lines of evidence indicate to avoid introducing potential biases (e.g. what do process based lines of evidence show?) Yes we rely primarily on observations. We have added some text regarding process-based analyses, notably in the section on hurricanes
6	47	1	• The chapter summary does not fully capture the chapter or the science. Suggest talking about the extremes affected by climate, the extremes not affected by climate, and those where the data isn't sufficient to establish a trend. We think our summary is appropriate
6	47	3	• “Over geologic time the climate system has generated an (essentially) infinite variety of weather patterns and extremes...” • Just because an event occurred before humans does not mean humans are not influencing the frequency or intensity of such events now. Additionally, if something has happened in the geologic record, but humans have never experienced it before, they may not be prepared for such an event. OK, but that has nothing to do with CO2. Adaptation to extreme weather is a separate but important issue
6	50	Figure	• The figure heading has “@RyanMaue” in the title. Looks odd to have a social media handle in the figure. Is the source peer reviewed? We have added reference to an older publication by Maue that describes the analysis
6	52	4	• Insufficient data is different than no effects. It would be helpful to be clear in instances like this whether a conclusion is because the data supports it, or because there is insufficient data to say the opposite. This is covered in the last para of the section
6	53	Table	• Could you also show a similar table with hurricane precipitation? Not in this round. Very hard to get historical rainfall going very far back
6	53	5	• The last two paragraphs show findings from NCA4. With the interest in focusing on recent literature, what does NCA5 say about these issues? Does it not cover this issue, does it say the same thing, does it contradict this finding? NCA5 statements are discussed in the body of the text, see pp 57ff.
6	54	1	• The heading of section 6.3.1 is a bit misleading as this is partly driven by warmer winters and fewer cold days. For the CONUS, the heading is accurate as demonstrated with observational analyses
6	58	Figure	• Figure 6.3.5 shows the number of days greater than or equal to 95F in 6-year periods. Why show this in 6-year periods? That seems like an unusual choice. Would this look different with 5, 10, or 15 year periods? The time series is 126 years long, which is evenly divisible by 6. The point is to compress the depiction of interannual (i.e. natural) variability and examine slower changes. In our decimal system, 5 or 10 years is more commonly used, but with 126 years of data, we did not want to leave an “orphan” column (one with fewer years) compared with the entire time series. Explained in the Figure caption
6	58	4	• “We measure “Heatwave Days” here as the count of all days in May-Sep each year that exceed the 90th percentile for that day and that lie within a period of at least six consecutive days.” • Why six consecutive days? Would this look different for 5 days, a week, 10 days? Six days seems like an unusual period to pick. As noted in the text we use a metric defined in NCA4 for heat wave days. Regardless, whatever parametric choice is made (i.e. 5 days, 10 days, 85th percentile, etc.) the 1920s to early 1950s dominate the occurrence of heat wave days.

			Added: The pattern of results show below does not depend on the choice of reference period.)”
6	58	4	• The dependence on and subsequent choice of reference periods is worrying. Can multiple reference periods be shown to show the dependence? There will be no change in the fundamental result no matter which reference period is chosen. If the entire period-of-record is used to calculate percentiles, there will be fewer percentile exceedences than if a cold reference period is chosen (as was done in NCA4). However, the shape of the outcome will be the same.
6	59	3	• “The NCA5 directs readers to the website https://www.globalchange.gov/indicators/heat-waves (USGCRP 2023)” • Broken link. The link was live when the report was written, but the Reviewer is correct that it is now broken. Fortunately, we included the figure from that link to demonstrate the unusual start date (1961) and the fact that the sample contained only large cities.
6	61	3 to 6	• This reads as a very selective analysis. With a very tight time constraint and the fact our analysis required the construction of serially complete datasets, we selected regions that were called out by NCA5 and/or the IPCC AR6 as unusual. In future versions we shall have more regions to examine (e.g. upper Midwest, Central Plains, Texas Hill Country).
6	67	2	• Is this section suggesting that climate change is causing the decrease in tornadoes? No, this section doesn’t engage in attribution
6	68	7	• This is another place where it would be better to reference newer literature and NCA5 instead of relying on NCA4. What has changed since then? NCA5 mentions drought many times, but in anecdotal ways without metrics for testing. For example, NCA5 pg 1-23 states. <i>“Between 1980 and 2022, drought and related heatwaves caused approximately \$328 Billion in damages (in 2022 dollars). Recent droughts have strained surface water and groundwater supplies, reduced agricultural productivity, and lowered water levels in major reservoirs, threatening hydropower generation.”</i> This statement simply says that the demand for water was not met by the human-built systems which manage water supplies – there is no metric here that measures a change in the natural water supply. The statements on which we focus relate to whether the supply has been changing – a metric related to the climate system.
6	69	1	• Figure 6.7.1, is this the same indicator used in AR6? We have clarified the text to refer to meteorological drought. AR6 speaks mostly of “Agricultural and Ecological Droughts” which are defined in for various regions as <i>“Agricultural and ecological droughts are assessed based on observed and simulated changes in total column soil moisture, complemented by evidence on changes in surface soil moisture, water balance (precipitation minus evapotranspiration) and indices driven by precipitation and atmospheric evaporative demand”</i>., so we are unsure what specific metric is referenced.” Elsewhere it simply uses the term “drought” or “Meteorological and Hydrological Drought.” AR6 pg 1075 “A drought is a period of abnormally dry weather that persists for long enough to cause a serious hydrological imbalance (Glossary; Wilhite and Glantz, 1985; Wilhite, 2000; Cook et al., 2018). Most droughts begin as persistent precipitation deficits (‘meteorological drought’) that propagate over time into deficits in soil moisture, streamflow, and water storage (Figure 8.6), leading to a reduction in water supply (‘hydrological drought’). Increased atmospheric evaporative demand increases plant water stress, leading to ‘agricultural and ecological drought’.

			The best we can say is the AR6 used a different metric than shown in Fig. 6.7.1 that likely varied from region to region. However, Fig. 6.7.1 has high correspondence with drought-related impacts.
6	69	3	• “In summary there is no evidence of increasing drought frequency or intensity in the U.S. or globally over recent decades.” • This statement is not supported by the citations presented here. AR6 finds that there are trends in agricultural and ecological droughts and this section does not contradict that finding, so this general statement about there being no evidence of increasing drought frequency or intensity is misleading. • AR6 SPM A.3.2 – “Human-induced climate change has contributed to increases in agricultural and ecological droughts in some regions due to increased land evapotranspiration (medium confidence).” Footnote, “Agricultural and ecological drought (depending on the affected biome): a period with abnormal soil moisture deficit, which results from combined shortage of precipitation and excess evapotranspiration, and during the growing season impinges on crop production or ecosystem function in general (see Annex VII: Glossary). Observed changes in meteorological droughts (precipitation deficits) and hydrological droughts (streamflow deficits) are distinct from those in agricultural and ecological droughts and are addressed in the underlying AR6 material (Chapter 11).” We have added “meteorological” to last sentence
6	69	4	• “The IPCC has not provided an assessment of wildfires.” • AR6 WGII SPM discusses wildfire, and WG1 SPM discusses fire weather. • AR6 WGII SPM – B.1.1, B.1.4, Fig. SPM.2, Fig. SPM.3, B.5.2, B.6.2, C.2.3, C.4.2, D.4.2, • AR6 WGI SPM – C.2.4 Restated: The IPCC has not provided an attribution analysis of wildfires
7	75	1	• “The largest sea level increases along U.S. coasts are Galveston, New Orleans, and the Chesapeake Bay regions” • How much? Are there quantifications? The figures show this
8	83	3	• “AR5 Working Group II (Cramer et al., 2014) makes the following statement:” • What does AR6 say on this topic? The science on attribution has evolved since AR5. The AR6 did not make an analogous statement, but the challenges haven’t been resolved
8	84	6	• “There are three areas of substantive criticism of the IPCC’s assessment of the causes of the recent warming...” • Are there citations that can be included here or are these criticisms attributed to the authors? The section describes this adequately
8	84	6	• “IPCC’s policy-informing...” • This phrasing is a bit odd. IPCC reports are policy relevant but policy neutral. This phrasing the direct policy in some way. Deleted policy-informing
8	90	3	• “For comparison, the IPCC estimate of forcing from the increase in atmospheric CO2 compared to preindustrial times is approximately 2.2 W/m2 (Figure 3.1.2).” • This is comparing different time periods. Figure 8.2 includes data for 2023 and 2024, IPCC wouldn’t include the most recent years since it was published in 2021. Suggest updating from the IPCC data to Forster et al. (2024) that updates these indicators. • Forster et al. (2024) “Indicators of Global Climate Change 2024: annual update of key indicators of the state of the climate system and human influence” https://doi.org/10.5194/essd-17-2641-2025 Updated
8	92	2	• “It is not easy to justify a new positive low cloud feedback that began emerging in 2015.” • Explain why this is not easy? Added, “since there is no obvious feedback trigger starting in 2015” e

8	93	4	• “Other columns of IPCC Table 12.12 report on whether anthropogenic signals are expected to emerge this century under RCP8.5, the most extreme forcing scenario. We have omitted these columns for several reasons.” • Can this be done for RCPs other than 8.5? The point of these omitted columns in IPCC Table 12.12 was to show that for some extremes we may not see an effect now, but will in the future. As it is presented here it implies future changes won’t matter. Agree 4.5 would have been better, but this is a query that should be directed to the IPCC
9	104	1	• IPCC AR6 WGII has an assessment of agriculture (both in the SPM and in Chapter 5), and the IPCC also has a special report on Climate Change and Land, that are more comprehensive, recent, and cover a larger range of the literature than discussed here. Please update this chapter to reflect these findings. Need a more specific point of challenge. Other reviewers have brought up specific topics that were either addressed by revisions or are already covered. I think this is one area that goes under the heading of critiquing the mainstream, based on peer-reviewed literature.
10	110	4	• Section 10.1 rightly points out that technological advances have substantially reduced losses from extreme weather events. We are better at forecasting, preparing for, and adapting to extreme weather than we were in the past, and these advances all help reduce impacts. However, our ability to do this in the future depends upon preparing for future changes – we can’t simply assume adaptation will continue, we need to provide information on future risks and how those risks are impacted by climate change in order to inform continued technological advances and future adaptation. Noted
10	111	1	• “In May 2025 NOAA announced it has withdrawn the Billion Dollar Disaster product from publication (Pielke Jr., 2025).” • It would be better to cite an official government source from NOAA announcing this withdraw instead of a blog post commenting on it. Agreed, but this is the best information available from a well-published expert
10	111	2	• Losses from extreme weather and climate events are driven by climate risk (the physical events themselves), exposure to those risks (population and infrastructure impacted by these events), and adaptation to those events (technological advances in forecasting, warning systems, and resiliency). Understanding these risks requires disentangling these drivers in order to prepare for the future. Noted. Such a risk assessment is beyond the scope of this report
10	112	1	• There are additional citations that focus on the net effects of heat and cold related mortality that would be worth discussing and citing in this section. • EPA. 2024. Draft Technical Documentation for the Framework for Evaluating Damages and Impacts (FrEDI). U.S. Environmental Protection Agency, EPA 430-R-24-001. • Cromar et al., 2022. Global Health Impacts for Economic Models of Climate Change: A Systematic Review and Meta-Analysis. Ann. Am. Thorac. Soc. 19, 1203–1212. https://doi.org/10.1513/AnnalsATS.202110-1193OC • Hsiang et al., 2017. Estimating economic damage from climate change in the United States. Science 356, 1362–1369. • Mills et al., 2015. Climate change impacts on extreme temperature mortality in select metropolitan areas in the United States. Clim. Change 131, 83–95 The Cromar meta-analysis included only 7 studies for the US all published before 2015, and not all of them examined both hot and cold extremes. We think the citations we have, which includes the EPA, are adequate.
10	113	7	• Section 10.3.2 has good points about the importance of energy affordability and how energy poverty impacts adaptation behaviors. Cong et al. (2022) is another good citation for this section. • Cong, S., Nock, D., Qiu, Y.L. et al. Unveiling hidden energy poverty using the energy equity gap. Nat Commun 13, 2456 (2022). https://doi.org/10.1038/s41467-022-30146-5 Citation added

11	Chapter	Chapter	• Much of this chapter if focused on older literature on SCC and on applications that fall outside of how the USG has actually implemented SCC. This chapter would benefit from a more explicit focus on EPA (2023) as it represents the latest state of the literature on SCC, shows how the USG applies the SCC for regulatory impact analyses, shows how the USG updated the older IAG era SCC as represented in EPA (2016) in response to the recommendations in NAS (2017), shows how uncertainty is incorporated into SCC estimates, and discusses areas of the literature that are on the frontier, highly uncertain, and not ready to be incorporated into the official USG estimates. • As currently written much of this chapter is focused on these highly uncertain areas of the literature that are not incorporated into USG SCC estimates (e.g. tipping points, and climate change impacts on economic growth). EPA (2023) discusses these issues and why they are not ready to be incorporated into the official estimates. • Furthermore, EPA (2023) estimates of the SC-GHG does incorporate climate benefits such as CO2 fertilization and reductions in cold mortality discussed elsewhere in this report, and this should be noted and discussed. • Finally, this section ignores areas of real controversy in the calculation of SC-GHG as it is used by the USG – namely the question of global vs. domestic benefits and the treatment of discounting when valuing benefits to future generations. These controversial issues deserve far more attention in this report instead of spending so much space on issues on the fringe of the literature that are not even included in USG SC-GHG estimates. • EPA (2016) “Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf • NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of The new discussion by the EPA simply rehashes longstanding issues. Switching to separable models like FaIR isn’t an advance, because everything still comes down to choice of ECS, discount rate, etc. They add some new damage components but as discussed they jumped on the M17 findings prematurely. Ch 11 focuses a lot on non-SCC topics like the relationship between temperature and growth because that’s been the focus of a lot of research. It’s not the case that this work is too new to be incorporated into SCC calculations. Moore and Diaz (cited) for example incorporated the Dell et al result into an SCC model. The problem is that the temperature signal in growth isn’t robust so economists aren’t convinced it belongs in the models. We don’t discuss the global vs local benefits issue mainly because standard SCC models have always assumed we should measure global effects and we are not offering an argument otherwise.
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11	116-120	Section 11.1	• This chapter has a heavy focus on the relation between climate change and economic growth and how this relationship factors into the SCC. There is an ongoing debate in the literature about persistence in climate damages as measured by changes in economic growth over time; however, these persistence effects on economic growth are not considered in the most recent version of the SC-GHG used by the USG – EPA (2023). This chapter generally ignores the existence of EPA (2023), it is mentioned once in passing, and does not inform readers that these controversial areas of current research are not included in government estimates of the SC-GHG. • EPA (2023) page 58 says, “Given the statistical insignificance of the estimated coefficient on the productivity indicator in the published Howard and Sterner meta-analysis, the SC-GHG estimates presented in this report do not rely on Howard and Sterner’s specifications that include productivity effects. This is consistent with the authors’ recommendations in the published paper, to only consider the inclusion of the productivity impact in sensitivity analysis. However, the question of whether the effects of climate change impacts (e.g., temperature, tropical cyclones, and other extreme weather events) on the economy are only temporary or persistent is an active area of research. Over the past decade, a host of empirical studies have found evidence of temperature changes having persistent effects on the economy (e.g., Dell et al. 2012; Burke et al. 2015; Moore and Diaz 2015; Deryugina and Hsiang 2017; Ricke et al. 2018; Burke and Tanutama 2019; Colacito et al. 2019; Henseler and Schumacher 2019; Kahn et al. 2021; Kumar and Khanna 2019; Bastien-Olvera et al. 2022); this is an important finding because even small changes in economic growth rates accumulate into large economic impacts over time.” Some are discussed in Section 11.1.2 but McKittrick’s review is more up to date.
11	116	1	• “Economists have long considered climate a relatively unimportant factor in economic growth, a view echoed by the IPCC itself in AR5.” • It would be good to update this to the relevant conclusions in AR6 to reflect the more recent literature. AR6 didn’t have an economics chapter comparable to AR5.
11	117	5	• This section makes an important point, much of the public does not understand that climate impacts are relative to projected future without climate change and need to be put in the context of economic growth and a future where our decedents are better off than we are today. O’Neill (2023) is a useful citation here, finding that, “Climate change research and assessments, including the most recent IPCC report, paint an increasingly dire picture of the future. However, the assumption that the future will be worse than the present may be wrong for many aspects of human well-being.” • O’Neill, B.C. Envisioning a future with climate change. Nat. Clim. Chang. 13, 874–876 (2023). https://doi.org/10.1038/s41558-023-01784-4 Citation added
11	119	3	• “Overall they could not detect a temperature effect on GDP or GDP growth, and they estimated the 95 percent confidence interval for the impact on global growth as of 2100 even under the exaggerated RCP8.5 warming scenario spans .86 percent to +388 percent. In other words the net effect is likely positive but too uncertain to distinguish from zero.” • This finding from Newell et al. (2021) needs to be contextualized with their complementary finding that models excluding growth effects and relating temperatures to GDP levels are far more certain. This is important to include since the actual USG application of SC-GHG does not include growth effects. • Newell et al. (20201) states, “Models relating temperature to GDP levels yield climate impact estimates that are far more certain. The best such models imply GDP losses by 2100 of 1–3%, consistent with damage functions currently embedded in the major integrated assessment models that underpin the U.S. social cost of carbon.” The discussion in this section is focused on the effect of dT on growth. The discussion of how dT affects the level of income is what 11.1.1 focuses on. It’s very regionally heterogenous so the small global average reported in Newell et al. isn’t very insightful.
11	119	6	• “To summarize, economists consider climate a relatively unimportant factor in economic growth, a view echoed by the IPCC itself in the Fifth Assessment Report.” • Need to update to reflect AR6 findings. See above

11	121		• “The concepts of estimation and uncertainty do not readily apply to SCC calculations.” • The discussion of uncertainty in IAMs should reflect EPA (2023) which incorporated many major advances in the treatment of uncertainty in integrated assessment modeling. See section A.8 of EPA (2023) for a summary of the quantified sources of uncertainty in the SCGHG estimates presented in EPA (2023) • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf Our point is that the key underlying parameters are uncertain, and the range of SCC estimates merely reflects those uncertainties. The fact that the EPA proposes ways to compute distributions of the SCC doesn’t affect this point, it follows from it.
11	121	3	• “Economists use IAMs to compute the SCC. Two of the best known are the Climate Framework for Uncertainty, Negotiation and Distribution (“FUND”, Tol 1997) and Nordhaus’ DICE.” • This is old literature. Given the advances since FUND and DICE were the leading SCC models, and this report’s focus on literature post-2020, this section should be updated to focus on the models used to calculate the SC-GHG in EPA (2023) which represents advances over the approach used in FUND and DICE in response to NAS (2017) recommendations. Added a mention of this. • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf
11	121	4	• “and a ‘judgmental adjustment’ of 0.5 percent for excluded impacts at 3°C warming” • EPA (2023) is the most up to date representation of the USG approach to SC-GHG incorporating the recommendations of the NAS (2017), and EPA (2023) explicitly does not included an adder for missing damages. This is another example of this chapter focusing on older less relevant literature, and it really should be comprehensively updated to address EPA (2023). Barrage and Nordhaus is a (2024) paper. We don’t endorse their approach, just describe it. But in some respects the EPA approach is already obsolete because the new Administration has abolished the SCC. • EPA (2023), page 59 states, “the model runs performed for this report do not adopt a 25% adder (as used in the DICE model (e.g., Nordhaus 2017)) to account for unknown or missing damages for the meta-analysis-based damage module.” • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. • NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of

11	122	6	• “Abatement costs: IAMs represent the cost to the economy of reducing CO2 emissions. If CO2 emission reductions are assumed to be inexpensive, then the model will conclude that the optimal policy should aim for deeper emission cuts and vice versa.” • IAMs such as DICE are often used in a mode of calculating the optimal level of abatement where they do indeed compare the SCC with the marginal cost of abatement to find the optimum. However, these abatement costs are not part of the SCC calculation, and as used by the USG for the purpose of regulatory impact analyses, this feature of these IAMs is not used. Instead the USG has other more appropriate tools for analyzing the costs of specific regulations. This distinction is important here as the assumptions about the cost of emissions abatement does not have any bearing on the calculation of the SCC. The paragraph has been rewritten to clarify this.
11	122	7	• “For example, in 2023 the U.S. Environmental Protection Agency raised its preferred SCC value about 5-fold over the estimates it had issued ten years earlier. This is not because new data had been collected or better mathematical methods had been invented, but because new assumptions had been used, and the validity of those assumptions was a separate question.” • This paragraph contains the only reference to EPA (2023). First, the characterization of this update as only because new assumptions are used is factually incorrect. EPA (2023) represents a significant change to how the USG calculated the SC-GHG moving away from the FUND/DICE/PAGE models used in the IWG era (see EPA (2016)) to a modular approach as recommended by NAS (2017). This chapter needs to address the NAS (2017) recommendations and the EPA (2023) response to those recommendations to capture how SC-GHG was actually used by the USG and how the literature has evolved over time. The tabulations in EPA 2023 p. 81 show that if they had not changed the Ag productivity assumption and added a large mortality cost they’d have ended up with SCC numbers very close to the 2013 IWG numbers. Assuming very low discount rates did the rest. Using the FaIR model with the DSCIM and GIVE damage modules wasn’t the key change, it was • EPA (2016) “Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf § NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of
11	123	2	• “It should also be noted that the SCC is focused on the social costs of CO2 emissions from fossil fuel use. It does not measure the private marginal benefits to consumers and society from the availability of fossil fuels. Public willingness to pay for fuels of all types indicates the value to society of reliable, abundant fossil energy.” • Two points to make about this section. First, the benefits to society generally accrue from the provision of energy services, not from specific fuels.” A distinction without a difference in this context. Second, the private marginal benefit of the availability of fossil fuels or energy services is not part of the SCC because changes in the cost and provision of the energy services should be part of the other side of the cost benefit analysis. The SCC is used to characterize the benefits of GHG emissions abatement, and the changes in the costs and availability of energy services are part of the cost of emissions abatement. Agreed, changed the wording to clarify
11	125	5	• “the uncertainty of SCC estimates doesn’t mean that other regulatory measures are inherently better or more efficient.” • ‘regulatory measures’ is a poor word choice here as it can be confused with the regulation itself instead of the metric used to assess the regulation. Changed measures to instruments

11	123-125	Section 11.1	• Section 11.2.4 has an interesting discussion of tipping points. This is an active area of research in the field, however it needs to be noted that tipping points or tipping elements are not included in the SC-GHG as used by the USG, see EPA (2023). • EPA (2023), page 3 says, “For example, the modeling in this report omits most of the consequences of changes in precipitation, damages from extreme weather events, the potential for nongradual damages from passing critical thresholds (e.g., tipping elements) in natural or socioeconomic systems, and nonclimate mediated effects of GHG emissions other than CO2 fertilization (e.g., ocean acidification due to CO2 emissions, tropospheric ozone formation due to CH4 emissions). Importantly, this update does not yet reflect interaction effects and feedback effects within, and across, natural and human systems. For example, it does not explicitly reflect potential interactions among damage categories, such as those stemming from the interdependencies of energy, water, and land use. These interactions and feedbacks, and others, were highlighted by the National Academies as an important area of future research for longer-term enhancements in the SC-GHG estimation framework.” Not necessary to say this since EPA is on hold from doing SCC calculations
12	129	1	• This chapter summary is misleading as it is describing change from today’s temperature rather than the effect on future temperatures. A change from today’s temperature is the future temperature. Not sure what the objection is.
12	129	2	• “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate.” • If global emissions were to go to zero tomorrow, CO2 concentrations would stabilize, and global temperature would be approximately constant. Net negative CO2 would result in reductions of concentrations and temperatures. In other words, while reducing global CO2 emissions to zero might not lead to near-term reductions in CO2 concentrations from today’s levels, it would stop future increases in CO2 concentrations. Consistent with what we stated.
12	129	3	• This section is focused on unilateral action, but needs to address questions related to collective action and individual actions by multiple parties when the benefits of abatement and the damages from emissions have extensive externalities. • Kotchen (2021) provides a theoretical perspective on the global vs. domestic SCC question and addresses questions related to how an individual country’s decisions are impacted by the expected choices of other countries given that GHG emissions are globally mixed the benefits of GHG abatement are shared widely. • Kotchen (2021). Which Social Cost of Carbon? A Theoretical Perspective. Journal of the Association of Environmental and Resource Economists. https://doi.org/10.1086/697241 An interesting line of thought but we can’t get into game theoretic models here.
12	129	4	• “Since that rate has been averaging about 50 percent of emissions in recent decades, a reduction of global emissions by 50 percent would (at least temporarily) halt the rise in atmospheric CO2.” • This may be addressed in earlier chapters that this reviewer has not read yet, but the standard framing is that stabilizing CO2 concentrations requires balancing emissions by sources and removals by sinks. Removals by sinks includes both natural sequestration and anthropogenic sequestration (e.g. afforestation if it can be done that increases the overall land sink removal, or direct air capture). It could be useful to clarify this here. The discussion is only an approximation for illustrative purposes
12	129	5	• “Lomborg (2016) estimated that full compliance with the Paris Accord would not stop warming, it would only prevent about 0.1C warming and delay hitting the baseline year 2100 temperature levels by about a decade.” • Note that the Lomborg (2016) finding is related to, “the of impact of the total, global emission cuts implied by all the submitted INDCs,” this is different than ‘full compliance with the Paris Accord’ as the INDCs analyzed in the paper are only the first round of Intended Nationally Determined Contributions submitted ahead of COP-21, and the Paris Accord requires additional Nationally Determined Contributions every 5 years. Since Lomborg (2016) only analyzes these INDCs, and parties have submitted two rounds of NDCs since then, suggest changing the wording here to, “... full compliance with initial commitments submitted ahead of the Paris Accord.” Changed.

12	129	Chapter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is PART 1] • Section 12.1 is titled, “The scale of the problem,” is framed around contrasting criteria air contaminants with CO2 emissions; however, there really are three separate issues that need to be disentangled: Stock vs. Flow. • The challenge here is that abatement costs borne by people today benefit people in the future – temporal externalities. • CO2 emissions are a stock pollutant, so impacts depend on the cumulative emissions to date, whereas traditional criteria are a flow pollutant and impacts depend on the emissions at that point in time. Emissions of a stock pollutant going to zero will not affect impacts at that point in time, as the stock remains unchanged, but will have large impacts in the future as the stock will cease to increase until emissions resume; whereas emissions of a flow pollutant going to zero will immediately eliminate impacts, but impacts will have no lasting effects on future impacts as they will immediately resume when emissions resume. • The sentence at the end of the second paragraph of this section reads, “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate.” This is conflating the expectations of how stock and flow pollutants work – if global emissions were to stop tomorrow, the fact that there would be no meaningful reduction in global CO2 concentrations is simply the nature of how stock pollutants work, but there would be very large impacts on future temperatures since the stock would cease to increase. Conflating isn’t the right word. We are pointing out the stock-flow issue. • The stock nature of CO2 emissions is a real challenge for justifying CO2 emissions reductions, but it is centered on justifying the costs of abatement being born by people today in order to create a stream of benefits that grow over time and primarily accrue to future generations. This leads to questions important questions about how decision-makers should think about inter-generational discounting, and what costs should or should not be borne today for the benefit of future generations that will potentially be substantially better off. Dealt with in the IAMs section • It’s worth noting that since CH4 emissions are relatively short lived, they behave much more like a flow pollutant than a stock pollutant. If CH4 emissions went to zero, concentrations would fall relatively quickly, and the temperature effects would happen on a much shorter timescale, but if CH4 emissions fully resumed, concentrations would return to previous levels there would be no lasting impact of the previous reductions. This is to point out that the stock vs. flow distinction also happens between different greenhouse gasses and is not purely a distinction between GHG emission and criteria pollutants. The CH4 case is interesting and we haven’t looked at it. Also natural sources and sinks are complicated for CH4
12	129	Chapter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is PART 2] • Globally mixed. • The challenge here is that abatement costs borne by people in one location benefit people in other locations – spatial externalities. • The next issue is that GHG emissions are globally mixed, so that emissions in any one location have impacts all over the world. This is a distinct issue from the stock vs. flow issue, as the CH4 example above showed a flow pollutant can also be globally mixed. One can also consider a stock pollutant that is not globally mixed, such as groundwater pollution that depends on the stock of contaminants accumulating in the groundwater not just the flow in any one time period as one would see in surface water pollution. • The globally mixed nature of GHG emissions is a real problem for justifying climate policy as the benefits of any one country’s actions primarily accrue to people in other countries. Conversely, a country benefits from the actions of every other country, not just their own actions. This is a problem of game theory and collective action, as unilateral action may not be justified even if collective action would be. It’s worth noting that this isn’t just a problem of scale – these same problems arise for globally

			mixed CH4 emissions even though as noted above they behave more as a flow pollutant, and would arise for any globally mixed pollutant regardless of the scale of the problem. There is an extensive literature on transboundary pollution that explores these issues. Agree with all this, but discussing these points wouldn't change our overall conclusions
12	129	Chapter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is PART 3] Scale. • The challenge here is that solving the problem requires enormous change and potentially enormous costs. However, individual actions need to be considered at the margin. • As discussed in this section and the comments above, stabilizing CO2 concentrations and stopping the increase in global mean temperature requires balancing anthropogenic emissions and removals by sinks. The level global mean temperature stabilizes at would generally depend on the cumulative CO2 emissions up to the point CO2 emissions on net go to zero (the stock of CO2 emissions), and the level of short-lived non-CO2 emissions at that time (the flow of non-CO2 emissions). This would involve an enormous change to the global energy system. The costs of this change would be highly dependent on the timing of reaching net-zero CO2 emissions – in 10 years by 2035 would involve crippling costs to the global economy, in 100 years by 2125 would involve a far more gradual transition and likely impose minimal costs when discounted back to today. • What is missing in this chapter is an acknowledgement that policy needs to be thought of at the margin. Do the marginal benefits of the policy equal or exceed the marginal costs? This is how economists think of these problems and the essence of how the government conducts cost-benefit analysis to inform decision-makers under E.O. 12866. The case study presented in section 12.2 poses the wrong two question. Showing that a policy's emissions reductions are small relative to global emissions, and the resulting impact on global temperatures is also small is tautological. No individual policy will solve climate change, but that does not mean that the individual policy is not justified. The relevant questions for decision makers are: (1) what is the cost of the marginal ton of emissions reductions by this policy? and (2) are those marginal costs smaller than the marginal benefit of a ton of emissions reductions? In practice, question (2) is very difficult to answer, and requires judgements about how to value benefits to Americans vs. benefits to the rest of the world, how to discount benefits that accrue to future generations, and how to consider the impacts U.S. actions have on the likelihood that other countries will take actions that benefit the U.S. These are difficult questions that need to be answered to justify climate policy, and this section would be improved by acknowledging that these are the questions that need to be addressed instead of the awkward argument that the problem is big, and individual policies are small therefore they can't be justified. Ch 12 is only focused on the scale problem. The reviewer is correct that even if the effects are small that doesn't mean they shouldn't be undertaken. Ch 11 is where the logic of cost-benefit analysis including marginal considerations is explored.

12	129	Chap ter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is the full comment] • Section 12.1 is titled, “The scale of the problem,” is framed around contrasting criteria air contaminants with CO2 emissions; however, there really are three separate issues that need to be disentangled: § Stock vs. Flow. • The challenge here is that abatement costs borne by people today benefit people in the future – temporal externalities. • CO2 emissions are a stock pollutant, so impacts depend on the cumulative emissions to date, whereas traditional criteria are a flow pollutant and impacts depend on the emissions at that point in time. Emissions of a stock pollutant going to zero will not affect impacts at that point in time, as the stock remains unchanged, but will have large impacts in the future as the stock will cease to increase until emissions resume; whereas emissions of a flow pollutant going to zero will immediately eliminate impacts, but impacts will have no lasting effects on future impacts as they will immediately resume when emissions resume. • The sentence at the end of the second paragraph of this section reads, “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate.” This is conflating the expectations of how stock and flow pollutants work – if global emissions were to stop tomorrow, the fact that there would be no meaningful reduction in global CO2 concentrations is simply the nature of how stock pollutants work, but there would be very large impacts on future temperatures since the stock would cease to increase. • The stock nature of CO2 emissions is a real challenge for justifying CO2 emissions reductions, but it is centered on justifying the costs of abatement being born by people today in order to create a stream of benefits that grow over time and primarily accrue to future generations. This leads to questions important questions about how decision-makers should think about inter-generational discounting, and what costs should or should not be borne today for the benefit of future generations that will potentially be substantially better off. • It’s worth noting that since CH4 emissions are relatively short lived, they behave much more like a flow pollutant than a stock pollutant. If CH4 emissions went to zero, concentrations would fall relatively quickly, and the temperature effects would happen on a much shorter timescale, but if CH4 emissions fully resumed, concentrations would return to previous levels there would be no lasting impact of the previous reductions. This is to point out that the stock vs. flow distinction also happens between different greenhouse gasses and is not purely a distinction between GHG emission and criteria pollutants. § Globally mixed. • The challenge here is that abatement costs borne by people in one location benefit people in other locations – spatial externalities. • The next issue is that GHG emissions are globally mixed, so that emissions in any one location have impacts all over the world. This is a distinct issue from the stock vs. flow issue, as the CH4 example above showed a flow pollutant can also be globally mixed. One can also consider a stock pollutant that is not globally mixed, such as groundwater pollution that depends on the stock of contaminants accumulating in the groundwater not just the flow in any one time period as one would see in surface water pollution. • The globally mixed nature of GHG emissions is a real problem for justifying climate policy as the benefits of any one country’s actions primarily accrue to people in other countries. Conversely, a country benefits from the actions of every other country, not just their own actions. This is a problem of game theory and collective action, as unilateral action may not be justified even if collective action would be. It’s worth noting that this isn’t just a problem of scale – these same problems arise for globally mixed CH4 emissions even though as noted above they behave more as a flow pollutant, and would arise for any globally mixed pollutant regardless of the scale of the problem. There is an extensive literature on transboundary pollution that explores these issues. § Scale. • The challenge here is that solving the problem requires enormous change and potentially enormous costs. However, individual actions need to be considered at the margin. • As discussed in this section and the comments above, stabilizing CO2 concentrations and stopping the increase in global mean temperature requires balancing
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		anthropogenic emissions and removals by sinks. The level global mean temperature stabilizes at would generally depend on the cumulative CO2 emissions up to the point CO2 emissions on net go to zero (the stock of CO2 emissions), and the level of short-lived non-CO2 emissions at that time (the flow of non-CO2 emissions). This would involve an enormous change to the global energy system. The costs of this change would be highly dependent on the timing of reaching net-zero CO2 emissions – in 10 years by 2035 would involve crippling costs to the global economy, in 100 years by 2125 would involve a far more gradual transition and likely impose minimal costs when discounted back to today. • What is missing in this chapter is an acknowledgement that policy needs to be thought of at the margin. Do the marginal benefits of the policy equal or exceed the marginal costs? This is how economists think of these problems and the essence of how the government conducts cost-benefit analysis to inform decision-makers under E.O. 12866. The case study presented in section 12.2 poses the wrong two question. Showing that a policy’s emissions reductions are small relative to global emissions, and <i>the resulting impact on global temperatures is also small is tautological. No individual policy will solve climate change, but that does not mean that the individual policy is not justified.</i> The relevant questions for decision makers are: (1) what is the cost of the marginal ton of emissions reductions by this policy? and (2) are those marginal costs smaller than the marginal benefit of a ton of emissions reductions? In practice, question (2) is very difficult to answer, and requires judgements about how to value benefits to Americans vs. benefits to the rest of the world, how to discount benefits that accrue to future generations, and how to consider the impacts U.S. actions have on the likelihood that other countries will take actions that benefit the U.S. These are difficult questions that need to be answered to justify climate policy, and this section would be improved by acknowledging that these are the questions that need to be addressed instead of the awkward argument that the problem is big, and individual policies are small therefore they can’t be justified.
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Ch	page	Para	Comment or Suggested Edit
2	5	Fig 2.2	The graph is not relevant to the discussion. It should only, at most, cover the time period since the last glacial maximum, which occurred ~20 kyr BCE, and common practice is to concentrate on the last 1000 years. Figure 2.2 has been deleted
3	11,12	Sec 3.1.1	There is no quantification of the effects of TSI and volcanic aerosols that would lead to modifications of the radiative forcing shown in the figures In ch 6 we discuss ranges of TSI forcing that even the IPCC acknowledges.
3	21,22	Sec 3.3	Many of the arguments and references are dated. Further, the challenge posed is to prove a negative, i.e. that the record used by AR6 is not biased by urban heat island effects. On the contrary, while verbally stating uncertainty, the authors cannot make a claim that the AR6 statement is false. Even if one were to accept the Soon, et al value of 0.89 deg C/century, the focus on the land surface warming completely neglects the contribution of the oceans to global surface temperature change, which must be considered in any discussion of surface temperature change. The underlying studies frame statistical tests appropriately to test for the presence or absence of an effect. Yes ,the literature is dated and the topic needs renewed attention. The question is bias in the land record, but no one is arguing all surface warming is due to urbanization.
4	30	Sec 4.4	The statement "TCR is more generally related to peak warming and better constrained by historical warming, than ECS." requires further context. While true that the "peak warming" rate achieves a maximum around 70 years, temperature increases continue for several centuries and approaches the ECS value asymptotically. Further, the Lewis (2023) arguments were placed in context by Sherwood and Forest (2024), that identified multiple recent ECS studies that showed, collectively, that the PDF in their original Sherwood, et al paper could not be narrowed. Additionally, the reference to Sherwood et al (2020) is incorrect. It omits many authors and the authors that are listed are not in the correct order. Reference to peak warming deleted.
5	37, 38	Sec 5.4	The analysis presented of the IPCC AR5 figure, Fig 5.6 in the current document, is outdated and should be removed. The issue IS addressed in the AR6, but not graphically, in the text reproduced by the authors. If the section is retained, it should be moved ahead of Section 5.3 to present the material in the correct order chronologically. The analysis in Fig. 5.6 matches the updated data in Fig 5.7, and it is relevant to show that the information was included in the AR5 but only in a figure in the Supplement. The order of presentation in the chapter is appropriate.
6	57	para 1	The conclusion "The rise in Tmin has been strongly related to the growing presence of manufactured surfaces around the weather stations over the last 100+ years (the so-called urban heat island effect; Section 3.3 and Spencer et al. 2025)." is only found in an author's self-citation of Spencer, et al, (2025) that does not appear in the references at the end of Chapter 6. Further, the trend of greater increases in Tmin relative to Tmax is documented and explained in Easterling, et al (1997). https://doi.org/10.1126/science.277.5324.364 ; Thorne, et al (2016) https://doi.org/10.1002/2015JD024584 . The trend cannot be attributed to UHI effects. We added citations to the literature to substantiate the point.
8	85	para 5	"... datasets with high TSI variability can explain more than 70 percent of the temperature variability since preindustrial times." Variability on what time scales? 11-year cycles? How would this impact the well documented surface temperature increase of > 1 deg C global temperature change since 1900?

			There is a whole spectrum of variability in TSI beyond the 11-year cycle. These are discussed in the papers we reference.
8	85,86,87	"Natural variability of large-scale ocean circulations"	The discussion neglects the influence of vertical mixing on surface temperature. The global ocean has warmed, as documented by increases in global ocean heat content, e.g. Murphy, et al (2009) doi:10.1029/2009JD012105 We do not understand the comment.
8	88,89	Optimal fingerprinting discussion	This section is hardly a balanced and objective review. The report authors are known opponents of optimal fingerprint approaches and have been a loud, but very small minority voice. It is interesting that even they conclude "...these analyses do not falsify results of the IPCC optimal fingerprinting method..." The point is that falsification would require redoing all the underlying studies. The findings however show that the method is flawed and the justification for relying on it is invalid.
8	90,91,92	Section 8.4	This discussion is incomplete and fails to take into account the extensive literature on cloud and surface albedo feedbacks.. There is an extensive discussion about the post 2015 period and recent record annual global surface temperatures, implying, but not stating, that recent changes are the result of natural variability, or decreases in atmospheric aerosol concentrations. Comparing the radiative forcing from these changes with long-term GHG forcing, particularly CO2 is misleading to the average reader. If the reduction in albedo can be tied to atmospheric cloud and aerosol changes, as the authors state, they cannot ignore the likelihood that the changes are the result of anthropogenic factors, i.e. sulfate aerosol reduction through cleaner technology and the well-documented positive low-cloud feedback. The discussion is incomplete because the underlying science is incomplete, as we emphasize. We are surveying a complex area of ongoing research without taking a strong position ourselves.

Full document			In the limited time allowed, this reviewer concentrated on sections related to the physical climate and climate change. Frankly, the document was discouraging. Secretary Wright wants a " ... a more thoughtful and science-based conversation about climate change and energy." I find that this report distorts the science in much the same way as the media coverage about which he complains. Most notable are the omissions or under-reported significant climate changes, such as sea-ice decline, changes in the global water cycle and increases in heat-stress due to increases in absolute humidity (from water-vapor feedback). Further, the examples used by the report authors are narrow and appear to be selected to emphasize uncertainty, while the more rigorously evaluated science that contradicts their limited discussion is ignored, perhaps because it does not fit their narrative. This is unfortunate, because I believe it detracts from the much needed discussion about the future, including energy policies, technologies and trade-offs. I encourage DOE to start the discussion by accepting the well-reviewed and broadly accepted scientific conclusions of the IPCC Working Group 1, with respect to the observations and analyses of climate change in the 20th and 21st centuries. Skepticism regarding predictions/projections of future climate based on posited scenarios is justified. As a member of the physical climate research community, I believe there are better uses for the models (and the computer resources they consume) than scenario projection simulations, to inform the discussion that is urgently needed about the future. Comments noted.
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Chapter Number	pg	para	Comment or Suggested Edit
Foreword	vii	4	The stated charge to the team was to summarize the current state of climate science, but in the Preface the team states that it chose to focus on topics that are downplayed in or absent from current assessment reports. To accurately describe the contents of the report, the Foreword should also state that the report is a summary of the things that the author team thinks have been downplayed in major climate assessment reports. Noted, the Preface has been modified. Our charge was not to summarize the whole of climate science.
Foreword	vii	8	The statement about climate change not being the greatest threat facing humanity is a value judgement. Since the Secretary criticizes others for blurring the line between scientific conclusions and policy recommendations in the second, fourth, and sixth paragraphs of this Foreword, it is hypocritical to offer a value judgement without clearly labeling it as such and noting that such conclusions must necessarily involve one's beliefs in addition to scientific information. We did not write the Secretary's foreword.
Exec Summ	viii	2	It is misleading (cherry picking) to only mention "global greening" (i.e., the influence of elevated CO2 on plant growth) here without also noting the impacts of elevated temperatures and changing precipitation patterns on ecosystem health and agricultural productivity. (This comment is also true of the underlying content on pages 3-7) This issue has been addressed with wording changes to acknowledge the other contributors.
Exec Summ	viii	2	It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems and fisheries. (This comment is also true of the underlying content on pages 8-9) The statement has been removed.
Exec Summ	viii	3	It is inaccurate to say that "scenarios of CO2 emissions have tended to overestimate observed levels". As the authors themselves note on page 15, it is impossible to reliably predict societal behavior regarding energy production and other sources of emissions, so the climate science community has never provided or suggested that there is a single predictive scenario against which future emissions could be judged. Rather, there has always been a range of projected emissions scenarios, and emissions have always tracked within the envelope of those scenarios. The authors make a reasonable point in the full text about the large number of climate studies that have used RCP 8.5, whereas actual emissions have recently been closer to RCP 4.5. This would be a more appropriate finding to include here in the executive summary. The point being made here is that observations have tracked the low end of the envelopes, a problem going back decades. See Figure 3.2.1
Exec Summ	viii	4	Stating that climate models "offer little guidance on how the climate responds to elevated CO2" is at best an unjustified (and at worst a biased) judgement given that the authors chose to focus only on the shortcoming and deficiencies of these models, and do not account for the progress made in improving the ability of these models to reproduce many key aspects of observed climate change. The same is true for all of Chapter 5. It is informative for readers to see key ways in which models fail to match observations especially those most relevant for policy making. The continuing wideness of the range of responses is an important limitation to their fitness for purpose.

Exec Summ	viii	5	Stating that climate models "generally run hot" is an inaccurate and misleading summary statement. A large number of papers and scientific assessments have validated the ability of climate models to accurately simulate many major aspects of global climate. Like all models, climate models are imperfect, and some models have recently shown a tendency to produce higher climate sensitivities--the IPCC AR6 acknowledged this "hot model problem" and there has been considerable discussion in the scientific literature about it and its implications for impacts studies. But this is a relatively recent phenomenon, and there could be other reasons for the recent mismatch (i.e., under-estimates of the reduction in aerosol cooling due to air pollution controls). A balanced scientific assessment would also note, for example, that climate model projections from the 1970s and 80s have accurately predicting the observed trend in global temperature over the past few decades. Our statements are substantiated by the Figures in Ch 5 (especially Figs 5.2 - 5.4). As we discuss, the problem of the tropospheric mismatch goes back decades.
Exec Summ	viii	6	It is misleading and inaccurate to say that most extreme weather events do not show long terms trends. It is true that some kinds of extreme events, like tornadoes, have not shown appreciable or detectable changes, and that changes in wildfire must account for changes in land management. But a "summary of the current state ofthe science" should acknowledge that there is clear evidence that heat waves are becoming more frequent and more extreme, extreme precipitation and nuisance flooding are becoming more common, etc. (This comment is also true of the underlying content in Part II) The chapter presents a great deal of data that substantiates our summary statement. We also provide clear indications on heatwave trends including where they are increasing in frequency. Our assessments match those in the IPCC and NCA documents.
Exec Summ	viii	6	It is misleading to state that the aggregate sea-level rise trend in U.S. tide gauges is not accelerating, because as noted in the same sentence, there are significant regional differences in SLR (primarily due to differences in land subsidence), so only looking at domestic gague data is insufficient to determine if sea-level rise--an inherently global process--is accelerating, with regional factors superimposed on that global trend. There is clear evidence that global sea level rise is accelerating. Moreover, while land subsidence has offset sea level rise in some U.S. regions, the opposite is true in others, and in those reasons the combined effects of sea level rise and subsidence are posing considerable risks to people and infrastructure in those regions...but this important context is omitted. (The same is true of the sea level rise analysis on pages 75-78.) We state that global sea level rise has accelerated in recent decades. The reviewer needs to provide evidence for the claim of acceleration. SLR is a regionally-heterogeneous phenomenon and we discuss the differences by location. We present tide-gauge data for many locations so readers can see the situation for themselves.
Exec Summ	viii	9	Most of the sentences in this paragraph are not factual in nature. For example, the call for uninterrupted observations of the global climate system is a research recommendaiton that is outside the remit of this report and is not supported by text within the document. The same sentence also implies that current emissions scenarios are not "realistic", which is not a defensible statement given that historical emissions have tracked within the envelope of previous emission projections (see comment above and Figure 3.2.2), and argues that climate models should address biases and uncertainties, which is something that every climate modeling team already spends an enourmous amount of time doing. If retained, the non-scientific portions of this paragraph should be moved to the Preface, and the misleading statements should be corrected. The paragraph has been moved to the end of Chapter 12. See above regarding emission scenarios.

Preface	ix	1	The focus on "whether carbon dioxide emissions endanger the U.S. public" is slightly different from the stated focus in the Foreward on "the Nation's climate". This distinction is important because climate change and its impacts outside of U.S. borders can endanger the U.S. public both directly (e.g., global processes affecting sea level rise in the United States, or the impacts of climate change on overseas military installations) and indirectly (i.e., impacts of climate change on international agricultural production and trade dynamics). The reference to endangerment has been removed.
2	3	1	The two summary statements provide an extremely narrow and misleading view of "direct impacts of CO2 on the environment" (the chapter title). The most obvious direct impact of CO2, in the context of climate change, is its role in global radiative forcing, which is covered in the next chapter but not mentioned here. The chapter should at a minimum be retitled, but better yet combined with the following chapter which discusses other aspects of increasing CO2. The effect of CO2 on the climate takes up the bulk of the report.
2	3	2	It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems, fisheries, and other processes. The evidence we cite shows that pH levels are in the range of natural variability. Whether the rate of change is, is much more difficult to establish because of the limitations of paleo records. Also the spatial heterogeneity is not subject to comprehensive measurement, which precludes straightforward assessment.
2	5	1	It is misleading to show (only) a graph of CO2 levels over hundreds of millions of years. These timescales are generally not relevant to processes and issues surrounding anthropogenic CO2 increases. For example the authors in multiple places make statements about CO2 levels during the last glacial maximum, but those fluctuations are undetectable on a graph with such a long timescale. The figure has been removed.
2	8	1	Acidification is not a misnomer...the word literally means to make something more acidic, which is what is happening. The authors may choose to argue that the term is misleading since the oceans are slightly basic, but that is not the same thing as a misnomer. We consider it a misnomer for the reasons stated. The oceans are not becoming acidic.
2	8	1	It is misleading and largely irrelevant to discuss ocean pH levels tens of thousands or millions of years ago, because that timescale is not relevant to the impacts associated with anthropogenic ocean acidification on ocean life. It is well documented that recent changes in ocean pH are happening ~100 times faster than natural fluctuations prior to human CO2 emissions, and marine species must adapt to changes in conditions on timescales of a few of their lifetimes, which is clearly not millions of years. The referee needs to provide specific sources for these statements. Also, it is a relevant point to make if current marine life evolved under conditions of much lower pH.
2	9	4	Similar to previous comment--changes in marine life over hundreds of millions of year has little relevance to the survival of marine species on decadal timescales due to anthropogenic ocean acidification. Are the authors trying to suggest that U.S. society would be well served by going back to conditions during the Jurassic? See earlier response.

3	13	2	The IPCC probably discounted the results reported in Connolly (2021) because that study included methodological errors that were documented in several subsequently publications, which the authors do not acknowledge. A serious assessment of TSI would not cherry-pick a single study, especially one that has been shown to include serious errors. The reviewer is probably referring to a comment by Richardson and Benestad, but Connolly et al. replied effectively to their critique.
3	14	4	It is unclear what the authors mean by "other natural sources of energy imbalance". If the authors are aware of a plausible additional source of energy imbalance they should state what it is rather than making vague statements without providing any evidence that such sources might exist. Surely the reviewer acknowledges that there are unknowns in the climate system
3	14	5	This is one of several places where the authors discuss the CO2 levels at which C3 plants begin dying in the context of the last glacial maximum. This is misleading, because there is no evidence that CO2 levels would have continued falling below the levels of the last glacial maximum, and irrelevant to the stated focus of this report, because they rebounded to 280 ppm many centuries before human activities began producing large amounts of CO2. The reviewer needs to provide evidence for the assertion that CO2 levels would not have continued falling.
3	15	1	The oceans and land surface absorb more like 60% of CO2 emissions. The 50% figure is repeated multiple times in the ensuing pages and should be corrected. We are unfamiliar with the 60% number; the sources with which we are familiar generally report numbers closer to 50%. The reviewer has not cited any sources for his or her statement.
3	20	2	The final sentence on this page is misleading and confusing as written. Most studies of the land carbon sink suggest that the rate at which it is increasing is declining, and several studies suggest that the ocean sink is declining. The authors should also explain the relevance of their statements here, because it isn't clear. Our statement is consistent with the sources we cite. Unfortunately the reviewer did not provide references.
4	26	6	The inclusion of a paragraph with high-level summary statements about climate policy here is confusing and inappropriate. This content belongs in chapter 11. We only make a brief introductory statement and otherwise defer the discussion to Ch 11.
4	29	1	The point about observed global temperature trends being consistent with both high-ECS high-aerosol and low-ECS low-aerosol worlds is an important one. It would be good to acknowledge that uncertainty in ECS is not just due to uncertainties in climate models, but also the lack of accurate measurements of pre-industrial aerosols and thus anthropogenic changes in aerosol forcing. And this uncertainty cuts both ways--if we live in a high-ECS world that has been "masked" by strong aerosol cooling, reducing air pollution could result in rapid warming (and this may be linked to the "hot model" problem as well). Agreed
4	29	2	The point about ECS values derived from past climate states (especially cooler ones) possibly not being totally representative of the current climate is another good point, one that would be good to acknowledge in their earlier and later discussions about uncertainty and the rationales for emissions reductions (e.g., on page 26 and in Chapter 11). Agreed.

4	30	1	The relatively shallow treatment on TCR relative to ECR here is puzzling, since the authors acknowledge that it is better constrained, and it is also a more relevant value for projected warming over the next several decades. The first sentence here also describes it as an observational constraint, but it is not, it is a metric that can be produced from either data or models (or both), and climate models are routinely used to run TCR experiments. ECS is more widely-used than TCR which is why we focus more attention on it.
5	32	1	A more accurate title of this chapter would be "deficiencies in climate models" because the authors focus almost exclusively on processes and features that models have struggled to reproduce, rather than a balanced assessment that also indicates what these models do well. We changed the title to take this into account.
5	34	1	Scaffeta (2023) has been widely criticized in the scientific literature for its methods and conclusions. These results should not be presented without acknowledging these concerns, or better yet, the authors should attempt to survey the literature on this topic rather than presenting results from a single controversial paper. The reviewer is referring to an exchange regarding a different paper. We are unaware of any published critiques of the Scafetta paper we cite.
5	34	2	Spencer (2024) is not a peer reviewed journal paper and is not really appropriate to include here when there are many papers on this topic that have been peer reviewed. The reviewer should have provided references. We are unaware of any peer reviewed papers that present the comparison we show. We provide traceable accounts for the underlying data, all of which is from official sources.
5	35	1	The statement that the signal for anthropogenic greenhouse warming emerges first and most strongly is not supported and is inconsistent with my understanding of climate dynamics. The following sentence is also dubious (and probably backwards) since models run with observed surface temperatures tend to produce much better mid-tropospheric temperature simulations. The statement about early and strong emergence of the CO2 signal in the tropical troposphere is in the IPCC TAR and subsequent reports. Even models constrained with observed sea surface temperatures produce excess amplification aloft.
5	36	1	In most places the authors correctly describe the discrepancy between models and observations as a mismatch, which is appropriate because observations of mid-tropospheric temperatures are also subject to uncertainty (as indicated in the error bars in Figure 5.4). This is one of the reasons for the IPCC confidence assessment noted in the following paragraphs. However, here and in a few other places in this section the writing implies that differences can be solely attributed to model deficiencies. We don't take a position on the ultimate cause however we do note that the biases are pervasive across models and multiple observational data sets.
5	37	1	This section should be combined with the previous one as it is really just elaborating on the same discrepancy between climate models and observational estimates of tropospheric temperatures. One section discusses the discrepancy of trends and the other discusses the discrepancy of amplification rates, which is why the sections are separate.

5	39	1	There has indeed been considerable controversy about this particular metric. It is curious that the authors choose to cite two older papers here (2008 and 2009) rather than the rich recent literature, especially since they went to the trouble of updating on of their graphics with 2024 data. Recommend including a more balanced assessment of this discrepancy, it's potential causes, and recent efforts to address it, as well as noting that climate models are able to accurately capture many other aspects of climate change. Again, it is unfortunate that the reviewer did not provide any citations to this rich recent literature. We cited the key papers we are aware of.
5	39	1	This entire section is very misleading as it cherry-picks a specific result and takes it out of important context. The reason why stratospheric cooling has slowed (and, at least in one study, even warmed) in the past two decades is due to the recovery of the ozone layer. This is clearly stated in the Philipona et al article cited by the authors and in the IPCC report. Additionally, satellite-based estimates of stratospheric temperature (which is data the authors highlight in the previous section) do not show the same trends. This section should be removed or amended to note that stratospheric temperatures are influenced by multiple factors and that a comprehensive analysis of stratospheric temprature trends is fully consistent with those projected under climate warming scenarios. We have added a sentence discussing the ozone recovery issue and make reference to the recent Santer et al. study.
5	41	1	Many observational studies have shown that snow cover is decreasing, and have explained why it is more meaningful and useful to look at spring trends in snow cover, as well as why observations of snow cover can be uncertain. The issue here is model projections versus observations. Again, the reviewer provides no citations.
5	42	4	The authors provide a relatively accurate survey of results regarding hurricane numbers and landfall frequency, which have indeed not shown any trends. But their analysis of hurricane intensity, which has been shown in many studies to increase, is lacking...the chart showing just estimated windspeeds of the top ten landfalling storms is really weak given the analytical talents of the author team. They also do not provide any discussion of the physical basis for why hurricane numbers may not be changing while the intensity of the strongest hurricanes is expected to increase, nor analyze any data in the context of those conclusions. The challenge for global intensity metrics is that the satellite record prior to 1980-1990 (experts disagree on the data quality during this period) is inadequate, which is why we focus on the Atlantic hurricane data. Also there is no theory for hurricane number; that is a topic associated with substantial uncertainty.
6	47	5	Long term persistence is not a recognized property or phenomenon associated with rainfall data. The use of such a statistical technique, especially one that is not widely recognized or used in the hydroclimate community, demands additional justification. We have rewritten the text to remove specific reference to LTP.

6	53	4	The authors have cherry picked results throughout this section. For example, they have selected only a few quotes from IPCC and NCA describing extreme heat. The absolute single daily maximum temperature for a given year, for example, is a poor statistic for assessing statistical changes in extreme heat (it would be like comparing the tallest person in each country to try to calculate change in average height). A complete and comprehensive review of the underlying assessments and the data it cites clearly shows that extreme heat has been increasing in North America. The reviewer fails to identify any data or conclusion from the IPCC or NCA that differs from our assessment, and fails to cite any sources to justify this comment.
6	56	1	The "climate less prone to extremes" is a misleading statement. If minimum temperatures are increasing faster than maximum temperatures (which is an expectation of climate change based on basic physical principals), then the difference between warm and cold extremes on many timescales is expected to decrease. There are reasonable points to be made regarding observational deficiencies, regional variations in extreme events, and the potential benefits of reductions in extreme cold, rather than coming up with misleading statistics. But we show that extreme heat has also declined since the 1930s – Figures 6.3.1 and 6.3.3 refute the reviewer's statement.
6	58	3	The NCA5 heading is not a controversial statement, it simply says that things are changing, which they are by the author's own admissions and graphs. It does not suggest pervasive positive trends, as the authors suggest it does. We're not sure what sentence the reviewer is referring to.
6	61	3	The statistical techniques used in the 2019 paper are highly non-standard for evaluating precipitation statistics, and the 2024 results have not been peer reviewed. The results reported in the NCA and IPCC and the underlying studies have clearly demonstrated that extreme precipitation is increasing. The 2019 paper uses ordinary least squares to compute the trend, and a standard variance estimator from the econometrics literature to assess significance. As we point out, we also find evidence of increasing precipitation averages and extremes but only when selecting certain start dates.
6	61	7	The relevance of the paragraph on 19th century and paleoclimatic rainfall events is unclear. If anything, the fact that such extremes have occurred in the past argues for more aggressive adaptation measures to ensure that damages won't be as high if they happen again (even notwithstanding potential changes in risk due to climate change). Note, however, that additional context is provided in the box that follows two pages later. We agree that discovery of extreme events in the 19th century records indicates that disaster planning may need to encompass a wider range of risks.
6	62	1	The choice of looking at (only) 5-day precipitation totals is questionable. Most rainfall events, including the most extreme and damaging precipitation events, are typically on a daily timescale. Again, the reviewer provides no citations or evidence. Our results are robust to different day intervals, and we refer to 1- and 2-day results as well.
6	68	3	Perhaps this is more germane to the sea level rise section, but nuisance (high tide) flooding due to sea level rise has been observed across much of the United States. This is a topic we did not address.

From: Judith Curry <curry.judith@gmail.com>
Sent: Saturday, August 2, 2025 12:37 PM
To: John Christy
Cc: Ross McKittrick; Steve Koonin; Travis Fisher; Roy Spencer; Charles Park; Joshua Loucks; Seth Cohen; Audrey Barrios
Subject: Re: DOE Internal Reviews

YES we need to emphasize your point 2

Note: I am working with the Tropical ListServ (mostly hurricanes), including Kerry Emanuel and Jim Kossin. After initial antagonistic responses, i'm working with them to collect relevant data-based papers

On Sat, Aug 2, 2025 at 9:16 AM John Christy <climateman60@gmail.com> wrote:
I'll start looking at this today.

Note 1: Among the emails I've received was this from someone called Justin Bass, who said, "John, I would like to interview you about your willful ignorance concerning the excessive burning of oil, gas, and coal that causes more deadly and destructive flash flooding, wildfires, and hurricanes in the 21st century."

I think he should start by working on his own interview skills.

Note 2: The CWG may be an opportunity to demonstrate to the public that science is a bit slow and messy as we are using an orderly approach with open comments and responses to get to the truth ... a system that is in great contrast to the way things are done in the media with its deadlines and agendas.

John C.

John Christy
Director, Earth System Science Center
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Alabama State Climatologist
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On Aug 2, 2025, at 9:48 AM, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I'll go over them later today

On Sat, Aug 2, 2025 at 10:37 AM Judith Curry <curry.judith@gmail.com> wrote:
Attached is a zip file of the edited DOE reviews. Probably good to have one more set of eyes look at this. Note: #1 and #6 required the most editing



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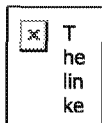
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Sent: 8/2/2025 2:36:46 PM
To: Steven Koonin [steven.koonin@gmail.com]
CC: Travis Fisher [travis.fisher@hq.doe.gov]; Ross McKittrick [ross.mckittrick@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; Charles Park [charles.park@hq.doe.gov]; John Christy [climatemanager60@gmail.com]; Joshua Loucks [Joshua.Loucks@hq.doe.gov]; Seth Cohen [seth.cohen@hq.doe.gov]; Audrey Barrios [audrey.barrios@hq.doe.gov]
Subject: DOE Internal Reviews
Attachments: DOE review responses.zip

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Pg	Para	Comment or Suggested Edit	
viii	2	The greening effect can't be due to increase in CO2 alone. The fertilization effect needs Nitrogen and phosphorous. There is observational[1] evidence that nitrogen available to plants is decreasing with increasing CO2 and thus acting to limit fertilization effect. Secondly, the greening of some portions of the planet are likely due to changes in precipitation patterns associated with changing climatic conditions and not entirely attributable to fertilization effect. We will also need to consider that the temperature effect on photosynthesis will also be a limiting mechanism to any continued greening due to fertilization in the future [2]. I recommend acknowledging that the greening is not attributable to CO2 alone and continued greening in the future with increasing CO2 is uncertain. Changed sentence to “Elevated concentrations of CO₂ directly enhance plant growth, globally contributing to “greening” the planet”	[1] Rachel E. Mason et al. Evidence, causes, and consequences of declining nitrogen availability in terrestrial ecosystems. Science 376, eabh3767(2022). DOI:10.1126/science.abh3767 [2] C.E. Moore, et al. The effect of increasing temperature on crop photosynthesis: from enzymes to ecosystems. Exp. Bot., 72 (8) (2021), pp. 2822-2844
viii	3	I am glad we acknowledge that CO2 causes warming, though I am not sure why we are not considering other energy sector related emissions that also cause warming (CFCs/HFCs, methane, aerosol effects). It is not clear what is meant by "CO2 emissions have tended to overestimate observed trends". This is not correct, the cumulative emissions track the RCP8.5 scenario the closest [3,4]. While there was a decrease in emissions during the Covid-19 period the emissions are now back on track following RCP8.5. This statement should clarify what is meant by the statement in the text. Rewrite sentence in the summary section to read “Climate change simulations require scenarios of distant future emissions. There is evidence that scenarios widely-used in the impacts literature have overstated observed and likely future emission trends.” On page 16 text added “Schwalm et al. (2020) defended the use of RCP8.5 on the grounds that cumulative CO2 emissions over 2005-2020 track it more closely than the lower RCP scenarios. They also argue that a modified version of the IEA scenarios closely track RCP8.5 in the coming decades. Hausfather and Peters (2020b) responded that the skill of RCP8.5 over those 15 years is due to offsetting errors in its representation of CO2 from fuel use and land use change, and the apparent agreement with IEA in coming decades is due to Schwalm et al. adding in very high land use emissions. The IEA’s own projected CO2 emissions track well below RCP8.5.”	[3] C.R. Schwalm, S. Glendon, & P.B. Duffy, RCP8.5 tracks cumulative CO2 emissions, Proc. Natl. Acad. Sci. U.S.A. 117 (33) 19656-19657, https://doi.org/10.1073/pnas.2007117117 (2020). [4] C.R. Schwalm, S. Glendon, & P.B. Duffy, Reply to Hausfather and Peters: RCP8.5 is neither problematic nor misleading, Proc. Natl. Acad. Sci. U.S.A. 117 (45) 27793-27794, https://doi.org/10.1073/pnas.2018008117 (2020).

viii	4	This paragraph seems to be talking about equilibrium climate sensitivity. The most recent model inter-comparison gives a wider range of climate sensitivities in the range of 1.8 to 5.7 and is wider than estimates of climate sensitivities that have been estimated from paleoclimatic and more recent historical datasets, in the range could be in the range of 2.3 to 4.5 K[5]. The higher sensitivity in the most recent model assessments are an area of active investigation by modelers, the feasibility of a higher range needs to be confirmed with additional observational and process scale modeling [6]. The range for climate sensitivities, 1.8-2.7, should be corrected to the most recent findings, 2.3-4.5. We should also recognize that the (a)earth is a complex system of systems (b)we can't do an experiment to find out what is correct or reduced the uncertainty. As we get better at extracting temperature records and CO2 concentrations from paelo data, there will be better reconstructions and possibly narrower range along with improvements in modeling that resolve many physical, biological and chemical processes as we get to higher and cloud resolving spatial resolutions. We discuss Sherwood et al. in Ch 4. Sentence changed: “Data-driven methods yield a lower and narrower range.”	[5] Sherwood, S. C., Webb, M. J., Annan, J. D., Armour, K. C., Forster, P. M., Hargreaves, J. C., et al. (2020). <u>An assessment of Earth's climate sensitivity using multiple lines of evidence</u>. <i>Reviews of Geophysics</i>, 58, e2019RG000678. https://doi.org/10.1029/2019RG000678 [6] Zelinka, M. D., Myers, T. A., McCoy, D. T., Po-Chedley, S., Caldwell, P. M., Ceppi, P., et al. (2020). <u>Causes of higher climate sensitivity in CMIP6 models</u>. <i>Geophysical Research Letters</i>, 47, e2019GL085782. https://doi.org/10.1029/2019GL085782
viii	5	This is again not true for the majority of the models in the AR6. Figure 7.19 in the IPCC AR6 report shows that majority of the models exhibit a range within the observational range. The models running hot in the most recent decades are the ones with climate sensitivities grate than 5K, which are 3 out of a total of 40 and it should be noted that about the same number of models also are running cold' compared to observed[7] Paragraph has been rewritten: The world’s several dozen global climate models offer little guidance on how much the climate responds to elevated CO , with the average surface warming under a doubling of the CO concentration ranging from 1.8°C to 5.7°C [Section 4.2]. Data-driven methods yield a lower and narrower range [Section 4.3]. Global climate models generally run “hot” in their description of the climate of the past few decades– too much warming at the surface and too much amplification of warming in the lower- and mid- troposphere [Sections 5.2-5.4]. The combination of overly sensitive models and implausible extreme scenarios for future emissions yields exaggerated projections of future warming.	[7]Hausfather, Z., Drake, H. F., Abbott, T., & Schmidt, G. A. (2020). <u>Evaluating the performance of past climate model projections</u>. <i>Geophysical Research Letters</i>, 47, e2019GL085378. https://doi.org/10.1029/2019GL085378
viii	5,6,7	There is very little dispute that these are challenging issues for climate science. Many of the issues identified here related to compound effects (subsidence and se-level rise; wildfire and forest management) that requires further scientific investigation. Identifying further research avenues/focus areas will be helpful to firm up some of the challenges faced in using the climate projections as discussed in the paragraph 9. There is no disagreement here.	

viii	9	The focus on uncertainty is relevant and should be emphasized in future research. However, as a reasonable policy pathways, making decisions in the face of these uncertainties is critical. Most of the climate uncertainties that we have confidence at this time can be considered Level 2 and Level 3 uncertainties, approaches such as scenario analysis (and others) are suggested and followed for making hazard and risk estimates for future conditions. For deep uncertainty hazards (for example tornadoes etc.) that we don't have enough data or capability to model, developing methods for assessing the uncertainty and risk should be a focus of future research. There is no disagreement here. See Curry's book Climate Uncertainty and Risk.	
2	3	The reason CO2 was identified as a pollutant is the health consequences of increased temperature, flooding and other climate impacts and not because of any direct affect on health dur to exposure to atmospheric CO2[8]. There is no disagreement here.	[8] https://www.cdc.gov/climate-health/php/effects/index.html
3	1/C hap ter su m ma ry	The summary should note that CO2 fertilization effects are limited by the availability of other critical plant nutrients (Nitrogen, Phosphorous). The fertilization effect is also constrained by higher temperature effecting photosynthesis[9] Added sentence: Other contributing factors included warming and increased nitrogen.	[9] Xinyuan Wei et al 2025 Environ. Res. Lett. 20 064013
3	3	The attribution of greening to primarily CO2 fertilization is questionable as per recent research. Specifically, in the Northern high latitudes (where the greening is most prominent), increases in temperatures due to climate change has been shown to provide the best explanation[10]. In the sub-Saharan region reforestation efforts and changing precipitation patterns lead to some of the observed greening (the great green wall) [11]. The attribution to CO2 fertilization should be qualified by noting the other present and emerging constraints. We cite Zhu et al attributing 70% of change to CO2 . That implies other factors matter as well.	[10]Liu, J., Wennberg, P.O. An emergent constraint on the thermal sensitivity of photosynthesis and greenness in the high latitude northern forests. Sci Rep 14, 6189 (2024). https://doi.org/10.1038/s41598-024-56362-1 [11] Francesco S.R. Pausata, Marco Gaetani, Gabriele Missouri, Alexis Berg, Danielle Maia de Souza, Rowan F. Sage, Peter B. deMenocal, The Greening of the Sahara: Past Changes and Future Implications, One Earth, Volume 2, Issue 3, 2020, Pages 235-250, ISSN 2590-3322, https://doi.org/10.1016/j.oneear.2020.03.002 .
3	5	This summarization ignores the compound effects of temperature, moisture and CO2 fertilization in assessing the impacts of CO2 increase on vegetation and crop yields. Many studies have shown that [12]. Making note of these compensating factors is required for a balanced view on CO2 fertilization effects on plants. This issue is addressed in Chapter 9	[12]Lesk, C., Anderson, W., Rigden, A. et al. Compound heat and moisture extreme impacts on global crop yields under climate change. Nat Rev Earth Environ 3, 872–889 (2022). https://doi.org/10.1038/s43017-022-00368-8

4	1	Chen et al. (2024)[13] conclude that "In the attribution analysis of LAI trend and growth rate trend, there were some differences between multiple linear regression model and partial correlation analysis at high latitudes in the northern hemisphere. Partial correlation analysis showed that LAI trend and growth rate trend in this region were mainly affected by temperature and radiation, while multiple linear regression suggested that CO2 was the dominant driver. The results of the partial correlation analysis seem more reasonable because some previous studies have shown that vegetation change in the high latitudes of the northern Hemisphere is mainly positively affected by climate warming. Multiple linear regression model performed relatively poorly in this region and might not fully identify the contribution of individual drivers. In addition, our model does not include the contribution of land management, which has been highlighted in some previous studies. Of course, the contribution of land management to LAI trend and growth rate trend may be implied in other drivers, such as the positive contribution of CO2 to LAI trend in PP and PN areas". We have added the Chen references. Our existing summary doesn't conflict with this. They conclude CO2 is the dominant driver globally but not the only driver.	[13]Xin Chen, Tiexi Chen, Bin He, Shuci Liu, Shengjie Zhou, Tingting Shi, The global greening continues despite increased drought stress since 2000, Global Ecology and Conservation, Volume 49, 2024, e02791,ISSN 2351-9894,
6	1	This again suffers from not acknowledging the effects of compound and often compensating phenomena that is occurring with the on-going climate change. For example [14] note that much of the Midwest any benefit from CO2 fertilization will be negated by temperature increases. [15] note that "Our results show that long-term physiological acclimation dampens the initial stimulation of plant net carbon assimilation to elevated [CO2], and of plant water use to warming." The topic of agricultural productivity is addressed in Chapter 9 It is not disputed that effects of dT go negative at high enough levels. The 2013 paper by Ruiz-Vera et al doesn't provide much general information beyond the FACE experiment site. The C14 data set I used is a global sample and takes both dT and dC into account.	[14]Ursula M. Ruiz-Vera, Matthew Siebers, Sharon B. Gray, David W. Drag, David M. Rosenthal, Bruce A. Kimball, Donald R. Ort, Carl J. Bernacchi, Global Warming Can Negate the Expected CO2 Stimulation in Photosynthesis and Productivity for Soybean Grown in the Midwestern United States , Plant Physiology, Volume 162, Issue 1, May 2013, Pages 410–423, https://doi.org/10.1104/pp.112.211938 [15] Lamba S, Hall M, Rantfors M, et al. Physiological acclimation dampens initial effects of elevated temperature and atmospheric CO2 concentration in mature boreal Norway spruce. Plant Cell Environ. 2018; 41: 300–313. https://doi.org/10.1111/pce.13079
8	1	The fallacy of these arguments in terms of PH changes and evolution is that the changes described in this paragraph occurred over millennia and the evolutionary process had time to adapt; here with climate change we are talking about changes in our lifetime, the speed of change is the issue. This will lead to collapse of some ecosystem and by the time adaptation takes place it will be millions of years and in a different climate - not the one we have now and that enabled the rise of humans. The chapter notes large regional and even diurnal variations in ocean pH. We already address the issue of short timescale variations on p. 8: "On the time scale of thousands of years, boron isotope proxy measurements show that ocean pH was around 7.4 or 7.5 during the last glaciation (up to about 20,000 years ago) increasing to present-day values as the world warmed during deglaciation (Rae <i>et al.</i>, 2018). Thus, ocean biota appear to be resilient to natural long-term changes in ocean pH since marine organisms were exposed to wide ranges in pH."	
5	Fig 2.2	A simple calculation will show us how misleading this figure is. It shows that over 600 Million years CO2 changed by around 6000ppm. That is a rate of change of 0.00001/yr; COE changed from 275 to 430 in the past 175 years, that is rate of change of 0.88ppm/yr. A change in the rate of over 10^5 in magnitude - there in lies the problem. We are seeing a rapid increase in CO2 that has never been witnessed and the ecosystem and huma society (which is at best 10K years old), may not be able to adapt to this rapid change. This figure has been deleted. We don't know what the rate of changes was on an annual or centennial time scale since the data are too low resolution. We have added the following sentence	

		“While the modern rate of change in CO2 is likely high compared to prior intervals, the geological evidence is that plants and animals evolved under much higher CO2 levels than at present.”	
12	Summary	The misuse of RCP8.5 as business as usual is acknowledged. However, this was never intended to be a no-policy or business as usual scenario but as a high-end baseline scenario. When dealing with interaction of physical systems with socio-economic projections (which tend to be highly uncertain and policy dependent), the development of this high baseline scenarios is intended to explore the uncertainty ranges that represent a high-end scenario[16,17]. As any engineer would acknowledge, this is a prudent approach when dealing with L3 and L4 type deep uncertainties and provide valid envelopes for assessing uncertainties and risks from high impact events/hazards. The rest of the statements here are uncertainties acknowledged by the climate scientists and included in developing projections and discussing the results[4]. Does the IPCC downplay the role of sun in climate change? The IPCC includes sun variability in all its assessments from the beginning and has been acknowledged as a potential but insignificant contributor. The comments do not imply any disagreement with what we have written. Extreme scenarios for models are useful for bracketing outcomes but our criticism (based on the literature) is the widespread use of RCP as a no-policy baseline; the reviewer acknowledges that was never its purpose. The IPCC’s assessment insignificance of the sun in climate change is based in part on use of low variability irradiance reconstructions that rule out it having any role. This is addressed in Chapter 8	[16]van Vuuren, D.P., Edmonds, J., Kainuma, M. et al. The representative concentration pathways: an overview. Climatic Change 109, 5 (2011). https://doi.org/10.1007/s10584-011-0148-z [17]Hausfather, Z. (2025). An assessment of current policy scenarios over the 21st century and the reduced plausibility of high-emissions pathways. Dialogues on Climate Change, 2(1), 26-32. https://doi.org/10.1177/29768659241304854 (Original work published 2025)
16	2,3,4,5	Please see above. The business-as-usual may be a misnomer but this is an 95% case that is typically included in any type of prudent uncertainty analysis, in particular given the difficulty of predicting the evolution of socio-economic and political conditions over the next 100 years. It should be noted the difference between RCP8.5 and RCP4.5 for mid-century conditions that is of particular focus for adaptation studies in not significant and most of the divergence in these two scenarios occurs later in the century. Implausibility is not equivalent to very unlikely (e.g. 95th percentile), but rather includes impossible or implausible assumptions. High impact hazards occur independent of atmospheric CO2 concentrations (Chapter 6).	

19	5	That the dynamic vegetation models need more development is acknowledged and is a defining challenge for Earth System Modeling for the next decade. There is no disagreement here	
22	3	As noted, Parker[18,19,20] has investigated the Urban effects on temperature records. The finding establish that by comparing warm and wind conditions world wide that the impact is negligible. However, as noted by authors, this literature hasn't progressed much over the last decade and much more attention needs to be paid to this question by employing newer models, datasets and analytical techniques available to us at present. The CWG Report addresses this concern. We agree with the reviewer that the literature stalled a decade+ ago.	[18] Parker, D. Large-scale warming is not urban. Nature 432, 290 (2004). https://doi.org/10.1038/432290a [19]Parker, D.E. (2010), Urban heat island effects on estimates of observed climate change. WIREs Clim Change, 1: 123-133. https://doi.org/10.1002/wcc.21. [20]Parker, D. E., 2006: A Demonstration That Large-Scale Warming Is Not Urban. J. Climate, 19, 2882–2895, https://doi.org/10.1175/JCLI3730.1.
28	2	We can all agree that there is a desperate need for developing higher-resolution climate models that can get to cloud resolving scale so that we can represent the cloud feedbacks correctly in the model and avoid uncertainties from parameterization and scale dependency of the parameters. This doesn't make these models useless. The models provide directions for further improvements and necessary changes to reduce the uncertainty bands over the ECS. The climate models are useful for research purposes. The CWG Report demonstrates that they are not fit for the purpose of policy making. There's no guarantee increased resolution will be the answer, but if ever a model appears that can deal correctly with clouds that will be quite something. .	

29	2	The databased approaches have mostly been robust with changes at the high end around 3-4C and at the low end around 1.8 to 2.5C as noted in the chapter. It will be challenging to make this range shorter given the data requirements and uncertainties in data over paleo/haloacene periods. It seems reasonable to estimate that we may have ECS in the range of 3 to 4K (higher than 3.5K being less likely [21]) at the higher end and this should not prevent us from planning and thinking on ways to prevent this possible scenario as it could have major consequences for humans across the planet. The Report acknowledges that 4C is a reasonable upper bound for the likely range	[21] Michael Mann, Our Fragile Moment: How lessons from Earth's past can help us survive climate crisis, Hachette Group Inc., 2024.
32	3	The models range over a factor of three in ECS comparing the most sensitive to the least sensitive models. However vast majority of the models are in 3 to 3.5K sensitivity range and it is probably not correct to assign all models the same amount of importance, given the fact that some of institutes participating in the exercise have different levels of capacity to develop and test models. Only 5 of the models are between 3 and 3.5C Some of the most reputable models have the highest values of ECS, including UK and US models The point made in this paragraph is that research over several decades has not reduced the range of model ECS. For observers who rely on model outputs this is very concerning and again goes to the question of fitness for purpose, as posed in the prior paragraph.	
34	1	While this analysis for the CMIP6 model set is accurate and focuses on a dataset that has shown higher ECS than previous iterations. it should be noted the models have exhibited considerable skill in predicting the subsequent GMST warming[22]. The criticism of the CMIP6 based high ECS models may be premature and probably will have to wait additional time before passing judgement. As noted in [22] these models have shown considerable skill when evaluated on their projections over the past 30-40 years after the projections were published. Figure 5.3 in the Report clearly refutes this assertion Hausfather et al. did examine early model-obs matches but only using models that had relatively low ECS. The Scaffeta analysis covered a longer interval (1980-2021) than the Hausfather et al. analysis of SAR (1995-2017) and TAR (2001-2017). Its findings line up with Fig 5.3 and the tropospheric evidence in Fig 5.4.	[22]Hausfather, Z., Drake, H. F., Abbott, T., & Schmidt, G. A. (2020). Evaluating the performance of past climate model projections. Geophysical Research Letters, 47, e2019GL085378. https://doi.org/10.1029/2019GL085378
36	1	A recent study attributes the bias to inter-annual availability and residual bias in the satellite record. The pre- and post 2000 have temperature records from two separate satellites and the discrepancy in the trends needs to be resolved[23] Chung et al. (using output through 2014 only) confirm the models' too-high warming rates and suggested two issues that might contribute to at least part of the discrepancy: (1) the differential phasing of natural, ephemeral events such as El Niños between models and observations and (2) a possible spurious cooling in UAH and NOAA/STAR satellite datasets around 2000. Regarding (1) we agree that the timing of major events like ENSOs diminishes the fidelity of models-to-observations comparisons for short periods, but now with 46 years of record as well as two major El Niño warm events since 2014 in the observations, the results shown in Fig. 5.7 are quite appropriate for comparison. Regarding (2) Christy et al. 2018 (and later Zou et al 2023) specifically examined the divergence around 2000 between UAH and NOAA/STAR vs. RSS and UW demonstrating that RSS and UW's use of the aging and drifting NOAA-14 satellite relative to the new, highly calibrated NOAA-15 sensor contributed to a spurious warming in RSS and UW. Be that as it may, CWG Fig. 5.7 is clear in noting all models overestimate the tropical temperature trend relative to observations – model trends being even more positive than those of RSS and the two Reanlayses (in addition to UAH and NOAA/STAR).	[23]Chung, ES., Kim, SJ., Sohn, BJ. et al. Multi-decadal climate variability and satellite biases have amplified model-observation discrepancies in tropical troposphere warming estimates. Commun Earth Environ 5, 342 (2024). https://doi.org/10.1038/s43247-024-01510-8

38	3	This is challenge we need to face and work on improving the parametrizations. The new era of super high resolution models would resolve the complex interactions of turbulence, transport and clouds and will provide less uncertainty[24]. However, this can't be used to invalidate the entire set of models, the models are performing remarkably well given the complex system that is being modeled. It should be noted the models do cover the range of the observations and it is not outside the envelope of model predictions. The Report does not address invalidating the entire set of models. Rather we address the fitness-for-purpose of the models for policy making Fig 5.6 shows that to the extent there is a match with observations, it comes from models with very little CO2 response. “However, this can't be used to invalidate the entire set of models, the models are performing remarkably well given the complex system that is being modeled.” This statement is not supported by the evidence unless and until “remarkably well” is metricized for us to examine and make a determination. The paper cited doesn’t exactly apply to the real world (looking at Fig 1 doesn’t give one much confidence in models), but does give insight into the various models as best I can tell.	[24]Merlis, T. M., Guendelman, I., Cheng, K.-Y., Harris, L., Chen, Y.-T., Bretherton, C. S., et al. (2024). The vertical structure of tropical temperature change in global storm-resolving model simulations of climate change. Geophysical Research Letters, 51, e2024GL111549. https://doi.org/10.1029/2024GL111549
40	4	Part of the problem here may be which part of the stratosphere is sampled and the importance of interannual a variabilities in the lower part of the stratosphere. [25] have shown that including the stratosphere as defined from 25 to 50km there is high confidence that the cooling signal caused by CO2 increase is detectable and beyond the noise levels of the natural and inter annual variability in the lowest part of the stratosphere. We should put this debate to rest. Santer et al. (2023 has been added to the references with this text: Santer et al. (2023) use updated data to show that a cooling trend has not re-emerged in the lower stratosphere.	[25] B.D. Santer, S. Po-Chedley, L. Zhao, C. Zou, Q. Fu, S. Solomon, D.W.J. Thompson, C. Mears, & K.E. Taylor, Exceptional stratospheric contribution to human fingerprints on atmospheric temperature, Proc. Natl. Acad. Sci. U.S.A. 120 (20) e2300758120, https://doi.org/10.1073/pnas.2300758120 (2023).
42	2	Given the large uncertainties in obtaining data over much of the Northern Hemisphere, using a smaller regional analysis to discount the models may be inappropriate. We should that this remains a question we need to resolve developing better datasets with more seasonal and sub-seasonal coverage to test the model on a global scale The reviewer’s points are fine but it is important in the context of this report to point out discrepancies in the way models on some key continental-scale metrics such as, in this case, snow cover. This section directly addresses a region that is important to estimates of the Social Cost of Carbon in the context of agricultural productivity, again reiterating that the models are not fit for the purpose of policy making.	

44	3	This statement from [26] refers to the fitness of global scale models to resolve regional scale features and argues for developing model at higher spatial resolutions. Using downscaling and other techniques additional insights can be gained at regional scales and provide information for a set of 'purposes'. However, we should work on getting to regional and local scales with GCM as quickly as possible. The current model structural forms may not be adequate for resolving all of these issues merely by increasing spatial resolution. Simulating change at regional to local scales depends on getting the internal variability of the ocean correct, which is only partly a resolution issue.	
47	2	Looking for trends or estimating trends in extreme events in current and future climate is not necessarily an attribution study. Estimating frequency, duration and intensity of events helps understand the changing range of the hazard (if there is one). An attribution would be to find to what extent a particular event is influenced or affected by increase in CO2. I would consider these two not to be the same. We explain the distinction between detection and attribution	
47	3	Attributing any single event to changing climate is perilous, agreed. Yes. .	
47	5	As noted by [26] there is not yet any strong evidence that LPT is a fact We have eliminated mention of LPT explicitly, but retain elements of the text surrounding long term variability.	[26]Cohn, T. A., and H. F. Lins (2005), Nature's style: Naturally trendy, Geophysics. Res. Lett., 32, L23402, doi:10.1029/2005GL024476.
57	2	I am not sure how one can conclude that the temperature extremes have decreased based on figure 6.3.4. If I understand correctly the Tmax-Tmin for each year was tabulated and a mean of this difference averaged over the 100+ years was subtracted from these values to get some thing like a anomaly. This anomaly seems to have moved from +3F to -3F over the course of q00 years and now trending upwards again. This suggests to me that there has been significant changes in the extremes over the years and the most recent trend is towards warmer highs? For each station and each year, the hottest day and coldest night are determined and their difference computed. These differences are then geographically averaged for the CONUS and then an overall average is removed to show the results as a type of anomaly. Reviewer 1 is correct, as indicated in the text, Tmin temperatures are almost universally rising more rapidly than Tmax, hence, the difference (or range) has declined overall. A check of CMIP6 models for the CONUS under ssp4.5 shows half with TMax rising faster than TMin and (obviously) half vice versa – so there is no clear signal from models that matches the observations. The flattening (or slight rise in the metric) in the past 20 years is clearly within the natural range, but does reveal an interesting stair-step pattern with rapid declines centered around the 1940's and 1990's and relatively flat periods in between. An explanation is under investigation, and a leading hypothesis is that there was rapid growth of manufactured surfaces around weather stations in the 1940s.	

		Then, in the 1960s-80s many stations were re-located to relatively rural airports, which then experienced subsequent growth in manufactured surfaces around their weather stations in the 1990s. Thus, rapid nighttime warming in the 1940s and 1990s.	
58	3	The NCA5 is suggesting that the western US is experiencing increase in extreme heat (page 57, para 4); it seems like figure 6.3.5 establishes the fact and not contradict. There was no claim of pervasive (all CONUS) increase in the report We have deleted the sentence “The NCA5 heading “The Risk of Temperature Extremes is Changing” suggests pervasive positive trends are now being observed in threshold temperatures, but that is not evident in the figures above.”Not worth going into more detail in this report	
59	4	The definition of heat wave as consecutive 6 days seems to be a special case. The standard definition is exceedance of 85 or 90 percentile for 2 or more days. I can't check with NCA5 as it was taken down from the web As correctly suggested by Reviewer 1, there are numerous ways to define a heat wave. CWG chose to follow one definition discussed in NCA4 (pg 191) and use 6 consecutive days with Tmax > 90th percentile so as to allow for consistent comparisons. However, changing the parameters will do little to alter the fundamental result that the 1920's to early 1950's contain the major heat wave events for the CONUS.	
60	1,2	Figure 6.3.6 establishes that heatwaves as defined here have increased in the west and have shown increasing trend all over CONUS in the past 50 years. [27] shows the results for the last 60 years and there is little doubt that there is an increase over most of the CONUS, again the NCA5 report is off the web; figure 6.3.7 shows the heat waves are monotonically increasing from the 1960. Including the longer data is only interesting in the dust bowl 1930 camouflage the signal somewhat for the Midwest and central plains. The problem of taking averages over large regions (for example entire CONUS) is that it kills the peak signals and smooths out the emergent climate change indicators. Doing continental averages to look for extremes is really not very useful. Secondly, there is no particular reason to assume that the climate change signal (i.e. the number of heat waves) should showing up 100 years ago, as the CO2 in the atmosphere started to be of significance in the last 50 years. As discussed in the CWG text, the EPA chart is (1) based on nighttime temperatures in the 50 largest US cities and (2) begins in 1961 which was the start of the coolest decade in over 100 years, thereby preconditioning the chart to have an upward trend. Urbanization is most clearly seen in nighttime temperature increases so this does not represent a change in the background climate, but more likely the local climates of cities. Rural areas show less nighttime warming. And, avoiding earlier warm periods does not provide information on the larger scale of natural variability. We have added a sentence at the end of Section 6.3 “Irrespective of the ultimate cause of regional trends, heatwaves have important effects on society which must be addressed, as we discuss in Chapter 10.”	[27] https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves

61	4	averaged over all stations in the region, none of these trend parameters is statistically significant'. This is again how one would be looking at statistics of extremes in precipitation. As we know, precipitation is highly heterogenous and location dependent. As observed there are trends even with the approaches chosen by the authors of this study compared to NCA5 and averaging that over and saying there is no trend seems disingenuous. We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area.	
62	2	same argument as above We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area.	
63	box	again the issue here is that we are talking about events that are happening in a short-time and over a small region. Averaging over time and space and develop statistics is probably not appropriate when we are talking about events such as the recent flooding event in Texas. If you average that event over 30 days, it will seem unremarkable. Extreme event totals are 1-day to 5-day,s depending on section discussed. The point being made in the Box is that if you use a too-short record you may underestimate natural variability. I'm not sure how the reviewer's comment challenges this.	
64	1	As noted in NCA5 and shown in the analysis presented in figure 6.4.4 there is a clear trend of increase in extreme precipitation in 12 of the 27 stations analyzed. Again averaging over the entire region is not the best method for picking extreme precipitation events that are local both in time and space. We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area. Also in this case we point out that the NE behaves differently than other regions.	

69	2	However, there is evidence that flash droughts, which last weeks have increased over the Northeast and Midwest [28] The paper referenced by Reviewer 1 begins with data so recent (1999) that it cannot provide evidence for long-term changes in drought as evidenced in the US Drought Monitor (DM) even though it suggests an increase in "flash droughts" over that period. Keep in mind, the DM is a product of subjective interpretation and objective measures - objective measures that have changed considerably during the past 25 years – thus is not metrically consistent. (One of the CWG authors was an official contributor to the DM for 15 years.) One would wonder what would the 1920's. 30's and early 50's reveal if the DM was operational back then? A more consistent metric is provided in CWG Fig. 6.7.1.	[28]Ronald D. Leeper, Rocky Bilotta, Bryan Petersen, Crystal J. Stiles, Richard Heim, Brian Fuchs, Olivier P. Prat, Michael Palecki, Steve Ansari
70	2	More recent analysis indicate forest loss due to wildfire accelerating over the recent past[29]. In particular there has been an increase in extreme fire radiative power with a 2 fold increase from 2003 to 2023 (period of satellite data availability)[30][31]. However, that these fires are not out-of-sample and there is a fire deficit as shown in figure 6.8.2 should be acknowledged. But this doesn't alleviate the concern that wildfire is leading to lot of socio-economic concerns and needs to be addressed[32] New sentence added: However there is evidence that the intensity of fires in some regions is worsening (Cunningham et al. 2024) and that wildfires resulted in a net loss of global forest cover over 2001-2019 (Tyukavina et al. 2022).	[29]Tyukavina Alexandra , Potapov Peter , Hansen Matthew C. , Pickens Amy H. , Stehman Stephen V. , Turubanova Svetlana , Parker Diana , Zalles Viviana , Lima André , Kommareddy Indrani , Song Xiao-Peng , Wang Lei , Harris Nancy; Global Trends of Forest Loss Due to Fire From 2001 to 2019, Frontiers in Remote Sensing.Volume 3 – 2022,2022. [30]Cunningham, C.X., Williamson, G.J. & Bowman, D.M.J.S. Increasing frequency and intensity of the most extreme wildfires on Earth. Nat Ecol Evol 8, 1420–1425 (2024). https://doi.org/10.1038/s41559-024-02452-2 [31]Patrick H. Freeborn, W. Matt Jolly, Mark A. Cochrane, Gareth Roberts, Large wildfire driven increases in nighttime fire activity observed across CONUS from 2003–2020, Remote Sensing of Environment, Volume 268, 2022,12777 [32]Parks, S.A., Guiterman, C.H., Margolis, E.Q. et al. A fire deficit persists across diverse North American forests despite recent increases in area burned. Nat Commun 16, 1493 (2025). https://doi.org/10.1038/s41467-025-56333-8
71	3	The question of forest management and its role on wildfire frequency and intensity is interesting and deserves further study. We agree	
80	1	The global mean sea-level was increasing at a rate of 0.08 inches/yr in 1993 compared 0.18 inches/yr in 2023, almost double the rate[33], which is approximately what is needed to meet the NOAA projections by mid-century and seems plausible. We don't judge it to be implausibl	[33]Hamlington, B.D., Bellas-Manley, A., Willis, J.K. et al. The rate of global sea level rise doubled during the past three decades. Commun Earth Environ 5, 601 (2024). https://doi.org/10.1038/s43247-024-01761-5

88	3	A possible reason the method used by IPCC (optimal fingerprinting) can be considered to address McKitnick criticism is in [34] We have added citation Chen et al. They mostly just reiterate my points. They propose a resolution to one part of the problem but it requires very restrictive assumptions.	[34]Chen, H., Chen, S.X. & Mu, M. A statistical review on the optimal fingerprinting approach in climate change studies. <i>Clim Dyn</i> 62, 1439–1446 (2024). https://doi.org/10.1007/s00382-023-06975-5
92	4	The role of clouds remains the single most uncertainty in climate modeling, I am glad this was acknowledged here. Agreed	
93	3	The substance of this paragraph was addressed in my comments in earlier sections. Some of the claims made here are either exaggerations of the usual practice (RCP8.5 being referred to as BAU) or the comment about not fit for purpose (a comment extracted from a publication that is calling out for cloud resolved models. Presumably the reviewer agrees RCP8.5 should not be used as a BAU scenario, so we are in agreement. The Palmer and Stevens paper nonetheless says the models are not currently fit for purpose.	
105	2,3, 4,5	The problem with both the FACE studies and the soybean. Maize and wheat studies cited here are that they don't consider the effect of increase in temperature, changes in precipitation, humidity and other environmental factors along with CO2 increases. These compound effects have been shown in wide number of studies [35] [36][37][38][39]. A meta analysis of the compound effects shows that increase in CO2, along with temperature, precipitation changes effects the quality of the cereal and yields[40]. Another recent study evaluated the impacts on C3 and C4 crops and conclude that CO2 enrichment for C3 crops could increase but will be compensated by temperature increase. CO2 fertilization effect was found to be small for C4 [41]. It is important therefore that we consider the compound effects on crop yields and not just focus on CO2 enrichment. The reviewer is correct that compound effects need to be considered, and indeed one of the problems with a lot of econometric papers on climate change and agriculture is they only look at heat and ignore the CO2 enrichment (Taylor and Schlenker being an important exception). Since our remit was impacts of CO2 emissions a brief discussion of FACE plot experiments and other CO2-only experiments is on topic. We discuss meta-analysis of multivariate (compound) experiments in Section 9.3.	[35] Ruiz-Vera UM, Siebers M, Gray SB, Drag DW, Rosenthal DM, Kimball BA, Ort DR, Bernacchi CJ. Global warming can negate the expected CO2 stimulation in photosynthesis and productivity for soybean grown in the Midwestern United States. <i>Plant Physiol.</i> 2013 May;162(1):410-23 [36] Levine LH, Richards JT, Wheeler RM. Super-elevated CO2 interferes with stomatal response to ABA and night closure in soybean (<i>Glycine max</i>). <i>J Plant Physiol.</i> 2009 Jun 1;166(9):903-13. [37]Večeřová K, Oravec M, Puranik S, Findurová H, Veselá B, Opoku E, Ofori-Amanfo KK, Klem K, Urban O, Sahu PP. Single and interactive effects of variables associated with climate change on wheat metabolome. <i>Front Plant Sci.</i> 2022 Oct 10;13:1002561. [38]Thomas, J.M.G., Boote, K.J., Allen, L.H., Gallo-Meagher, M. and Davis, J.M. (2003), Elevated Temperature and Carbon Dioxide Effects on Soybean Seed Composition and Transcript Abundance. <i>Crop Sci.</i> , 43: 1548-1557. https://doi.org/10.2135/cropsci2003.1548 [39] Lesk, C., Anderson, W., Rigden, A. et al. Compound heat and moisture extreme impacts on global crop yields under climate change. <i>Nat Rev Earth Environ</i> 3, 872–889 (2022). https://doi.org/10.1038/s43017-022-00368-8 [40] Ben Mariem S, Soba D, Zhou B, Loladze I, Morales F, Aranjuelo I. Climate Change, Crop Yields, and Grain Quality of C3 Cereals: A Meta-Analysis of [CO2], Temperature, and Drought Effects. <i>Plants.</i> 2021; 10(6):1052. https://doi.org/10.3390/plants10061052 [41]Rezaei, E.E., Webber, H., Asseng, S. et al. Climate change impacts on crop yields. <i>Nat Rev Earth Environ</i> 4, 831–846 (2023). https://doi.org/10.1038/s43017-023-00491-0

106	1	Taylor and Schlenker 2021 also note that 'Climate change will likely have negative impact on agriculture in aggregate, especially in regions exposed to extreme heat. And the CO2-driven yield increases may be offset by effects on food nutrition and quality'. However, the results for US have been a net positive in the recent past but not true in the lower latitudes. Extreme heat may be a net negative, but thus far the overall effects have been positive. Regarding nutrition loss see Section 9.4	
111	1,2	The criticism of NOAA Billion dollar map is likely warranted as it was never completely transparent how the data was generated. However, changing the baseline assumption and refactoring the data using a different set of criteria to make the effects smaller also doesn't make sense. We should continue collecting this data and make the data accessible for researchers and peer review. Figure 10.1 doesn't address these issues, it is another methodology with unknown provenance of the data. We agree that data collection, dissemination and transparency are key. Fig 10.1 is traceable as an indicator though we don't regard it as the final word on the subject either. .	
117	3	Climate change can be expected to increase cold weather extremes in regions that have not been exposed to these effects Not sure what the reviewer's point is.	
118	3	The same Nobel prize winning model in its most recent study concludes that [42] "We conclude with three results relevant for climate policy. First, both current policies (base run) and the extended Paris Accord fall short of limiting global warming to 2 °C or to the cost-benefit optimal level. Second, the economic stakes in global climate policy are substantial, with estimated net present value of economic benefits around \$120 trillion from the cost-benefit optimal policy. Third, once differences in discounting are considered, the baseline DICE-2023 estimate of the social cost of carbon (\$66/tCO₂ for 2020) aligns closely with other recent estimates". Obviously this is the latest and the current version of the model and these results are quite different from those discussed on this page. These conclusions should also be included in this discussion to avoid selective reading of the literature. We discuss Barrage and Nordhaus (2024) on p. 121.	[42]L. Barrage, & W. Nordhaus, Policies, projections, and the social cost of carbon: Results from the DICE-2023 model, Proc. Natl. Acad. Sci. U.S.A. 121 (13) e2312030121, https://doi.org/10.1073/pnas.2312030121 (2024).

120	1	Similar empirical studies [43] point to "Using an empirical approach that provides a robust lower bound on the persistence of impacts on economic growth, we find that the world economy is committed to an income reduction of 19% within the next 26 years independent of future emission choices (relative to a baseline without climate impacts, likely range of 11–29% accounting for physical climate and empirical uncertainty). These damages already outweigh the mitigation costs required to limit global warming to 2 °C by sixfold over this near-term time frame and thereafter diverge strongly dependent on emission choices. Committed damages arise predominantly through changes in average temperature, but accounting for further climatic components raises estimates by approximately 50% and leads to stronger regional heterogeneity. Committed losses are projected for all regions except those at very high latitudes, at which reductions in temperature variability bring benefits. The largest losses are committed at lower latitudes in regions with lower cumulative historical emissions and lower present-day income". This study uses more of the daily temperature precipitation from 1600 hundred locations world wide instead of global means. There are numerous studies that show the cost, many described in the COP 21 and follow-on meetings The Kotz et al. paper is subject to a cautionary notice at the Nature website that “the reliability of data and methodology presented in this manuscript is currently in question.” https://www.nature.com/articles/s41586-024-07219-0 The literature showing growth effects of temperature increase is pretty robust. And though we don’t cite it, there is a new paper just accepted at Climate Change Economics by McKittrick and Devina Lakhtakia adding to the evidence using 2 newly-constructed global data bases.	[43] Kotz, M., Levermann, A. & Wenz, L. The economic commitment of climate change. Nature 628, 551–557 (2024). https://doi.org/10.1038/s41586-024-07219-0
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Page	para	Comment or Suggested Edit
		The report indicates numerous examples of uncertainties in climate science. It would be extremely helpful if these undertainties were made more explicit, listed in a concluding section, and prioritized in some way - what are the top 10 priority research areas? If the opening remarks by Secretary Wright and the title pointed to uncertainties and the need for more research, I believe this report will be better received. As I read the report and left review comments below, I bolded items where I gather the authors imply that research is needed. Consider including these kinds of statements throughout and adding a summary. An interesting suggestion but with the time constraints I suggest this be deferred to a separate report.
viii	3	This would be more correct: "Some scenarios of future CO2 emissions overestimate observed levels" Sentence has been removed
viii	5	This would be more correct: Some detailed climate models run "hot" in their simulation of the climate of the past few decades, while many have underestimated the amount of surface warming. More research is needed to select the most skillful and reliable models. The need for more research on model development is implicit. Again, this would be a good topic for a separate report.
viii	6	Need reference for: "Claims of increased frequency or intensity of hurricanes, tornadoes, floods, and droughts are not supported by historical data." More research is needed to identify how frequency and intensity of weather events are affected by environmental conditions. The ES statements are all supported by the document chapters but suggest we add references to specific sections.
4ff		It is misleading to separate the photo-chemical effects of CO2 from the temperature effects. Extreme heat is hard on plants, causing them to lose water, close stomata, etc. It depends on the plant and the degree of heat. More research is needed to understand how the temperature (mean and variability) affects plant productivity and resilience. 1st paragraph of Section 2.1, Added sentence "Here we focus just on CO₂ fertilization; research on combined effects due to temperature and precipitation changes are discussed in Chapter 10."
7		Again it is misleading to separate the CO2 and the temperature effects on the oceans. The warming surface waters is having significant impact on ocean fish and habitats due to the overall increase in global temperatures This section is specifically on changing alkalinity. We haven't included a review of temperature effects on fish populations: it is one of the impacts topics we were not able to survey.
14	4	More accurate to say "because their effect remain largely unknown". Good examples include natural aerosols (sea salt, dust, biogenic aerosols). Are there others to mention? More research is needed to understand radiative effects of both natural and anthropogenic sources of radiative variability throughout the atmospheric column. Sentence added: "Natural sources of global energy imbalance other than volcanoes and total solar irradiance (TSI) are not included in these graphs because their effects remain largely unknown."
17	figure	What scenarios are the models using in this figure? SRES, as stated in text, also others including Hansen A,B,C and others as described in the Hausfather et al. paper.
19		Vegetation is only one way that CO2 is accommodated by land processes, the other is through soils and microbial processes Microbial dynamics is complex and challenging to understand but may also be a way to boost CO2 absorption by soils (which also enriches the soil nutrients!). More research is needed to better understand how plants and soil systems remove CO2 from the atmosphere.

		Noted.
19	5	More research is needed to improve the understanding and representation of land systems, carbon and nutrient fluxes in models. Noted.
20		Carbon uptake by oceans and ocean ecosystems is less well studied and modeled. The lack of spread of carbon in ocean models may result from insufficient information, ocean biogeochemistry, ecosystems and model development. More research is needed to study and model carbon, nutrient and ecosystem processes and dynamics in ocean models. Noted.
		More research is needed to map warming trends in urban, non-urban and other environments and to ensure accurate representation of regional and global trends in temperature. Noted.
27	2	"This practice" - need to clarify whether this refers to "emergent property" or discarding. I believe the authors mean the latter, but it should be made more clear Sentence rewritten: "Parameter tuning to yield an ECS target was commonplace for the models used in AR4; modelers have moved away from this practice with time."
27	3	"assumed positive cloud feedback" - this is an emergent property too, based on simulation/observation. Should be rephrased to not use the word "assumed". Further research is needed to better understand and model how clouds change with temperature and what the feedback effects are on the radiative balance. Need to clarify if cloud feedbacks are assumed, imposed or both? Can be handled editorially by deciding whether to delete "assumed" or not; deleting it allows it to remain as an implicit modifier.
		Further research is needed to narrow the uncertainty on climate sensitivity, both using models and observations. Noted.
33		The text and figure refer to 33 models, which would include the best and worst. How much does the uncertainty/range change for a subset of best-performing models? The modeling community doesn't have a leaderboard of best-to-worst models. Some of the "prestige" models from the US and UK have very high sensitivities, but they are preferred by many users for particular applications.
34	figure	How many models are included in each case? High ECS 14, Medium ECS 11, Low ECS 13. Added to Figure caption.
36	figure 5.4	How are the lower and mid-troposphere defined? Standard definitions in the paper: LT surface to ~9km, MT surface to ~15 km. Added in the Fig caption.
37	4	"excess amplification" - amplification of what? And Figure 5.6 shows tropics, is this bias only tropical? Sentence changed: "Another important model-observational discrepancy is the excess amplification or warming with altitude..." The bias is only observed in the tropics but the amplification pattern is only predicted in the tropics. Also bear in mind the tropics is nearly half the atmosphere and is where most solar energy enters the climate system.

38		Further research is needed to improve how models represent clouds and dynamics; additional observations are also needed to improve these representations. Noted.
42		Further research is needed to improve how models represent planetary albedo to align with observations. Noted.
		The greater concern with hurricanes is the amount of moisture they carry and drop after landfall, i.e. flooding. While this is an active area of research, it is worth noting that this may be the bigger issue for hurricane change with warming This is covered in the AR6 assessment as quoted, as it's one of the intensity metrics. Currently too little data to assess for trends.
56-57		The concern for many are the extreme hot temperatures without night-time cooling that provides an opportunity for recovery. This section doesn't address this. In this regards, the focus on the difference between extreme hot and extreme cold is misleading when generalizing about decrease in extremes (figure 6.3.4) - the decrease is because we don't have as much extreme cold. This metric is covered by the data in Sct 6.3.3.
60		Combining heat and humidity as a measure of extreme heat is not unusual since it is this combination that is most impactful to human health - the body cannot cool if the humidity and heat are both high. Since a warmer atmosphere holds more moisture, and CO2 causes heat (and therefore moisture) to increase, this combination is a relevant assessment of the effects of CO2 on extreme conditions that make it difficult for people. Also combining with urban regions is helpful since that is where most people live. These points are not made in the report and are important. <u>Sentence</u> be changed to read: "Given the heatwave definition and urban focus, while these increasing values since 1960 point to a growing human impact they are not informative about long term trends or..." Added sentence at end of paragraph (Irrespective of the ultimate cause of regional trends, heatwaves have important effects on society which must be addressed, as we discuss in Chapter 10.) this should address reviewer concerns.
		Patterns and variability of precipitation are poorly understood and models are particularly challenged to represent and predict precipitation, further research in this area is needed Noted.
		The authors rightly describe the extreme uncertainty regarding sea level rise. It would be helpful to add some information about the complex, highly nonlinear and uncertain processes involved with ice-sheet dynamics and ice-sheet - ocean interactions that are especially key for Antarctica. More research is needed to study and model ice sheet dynamics and ice-sheet ocean interactions. Noted. Canvassing ice sheet and ocean dynamics in that much detail beyond our scope but would belong in a separate report.
84	3	Further research is needed on climate variability, effects of ocean circulation, solar variability, model simulation of variability and statistical methods. Noted.
87-88		Anthropogenic aerosol effects may also influence the inflections in temperature in ways that are challenging to account for Noted.
91	2 and 3	Reductions in aerosol indirect (cloud brightening) effects may also explain the reduced planetary albedo, not just from ships but from reduced fossil fuel aerosols coming from the continents, China and east asia especially. This paper describes the reduction in aerosols https://www.nature.com/articles/s41612-023-00488-y This is another area that needs further research! Noted.

94	table 8.1	What are the numbers in the 3rd column? Please include in the caption. Good point. Added to caption: “Numbers refer to footnotes in original source that specify locations or region-specific confidence levels.”
95	2	I don't see an inconsistency between what Ch 11 and Ch 8 say. The first is about precipitation, droughts, tropical cyclones, heat - overall. The 2nd (ch 8) is about specific types of events in specific regions. Suggest to soften the statement about the contrasting assertions. Sentences at issue are “Evidence of observed changes in extremes and their attribution to human influence (including greenhouse gas and aerosol emissions and land-use changes) has strengthened since AR5, in particular for extreme precipitation, droughts, tropical cyclones and compound extremes” versus “No evidence of emergence in the historical period of a change in river floods, heavy precipitation, drought, fire weather, severe wind storms, and tropical cyclones”. It seems apparent to me that these statements are in conflict.
		The science of attribution of extreme events is challenging and computationally expensive; this is an area where further research is needed with potential to use AI to improve statistics Noted. Not sure about the computationally intensive point: many just run univariate GEV models and overinterpret the results. AI won't fix the bad methodology.
104		This section seems to gloss over many key points. Certainly there are limits where extreme heat and drought (water is key) could be detrimental to crops. It also depends on which crops. There is extensive literature on how certain crop viability is shifting. So a region with particular crop experience and cultivation may no longer be able to sustain that agriculture. There is cost to shifting crops across regions and farmers that needs to be accounted for. And water is key - is there enough water in various regions for energy (power plants need water) as well as agriculture when conditions are very hot for sustained periods? The comment seems to be about the validity of the underlying literature rather than our summary of it. The econometric lit tries to synthesize patterns over large areas to get at overall trends, rather than the agronomy focus on specific sites and crops.
111		Severe weather continues to disproportionately impact lower income communities as well as business that requires outdoor exposure. A thorough analysis would need to include these points and I recommend adding this caveat to the section. This is specifically addressed in Section 10.3.2
		Related to my previous comment, deaths due to extreme heat conditions appear to be increasing, particularly for certain populations and for those with underlying health conditions (which can be hard to detangle when attributing mortality). For example https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2792389 Again this topic is specifically addressed in Section 10.3.2
114		An additional concern is if the grid fails under either extreme heat demands or cold/severe-storm events, the impact on communities will not be uniform and depends on grid infrastructure which can be better in more affluent communities Good point. We don't discuss what makes for grid stability versus instability, especially in the context of many jurisdictions closing reliable power plants and opting for intermittent renewables, but the correlation between extreme weather and the likelihood of power failure is an important topic.
		The impacts of sea level rise and coastal inundation on coastal communities and in low-lying countries should be addressed. This will have impacts particularly on certain countries/regions but also on world economics Good point. The topic is germane but runs into the limits of what we can cover in our limited time. To some extent it is covered in the economics chapter since IAM damage functions include effects of sea level rise on coastal areas.
		Research is needed to better understood the likelihood and impacts of various tipping points, including changes to ocean circulation patterns, ice sheet acceleration, sea-ice loss, die-off of tropical forests, thawing of permafrost, etc. Noted. Hopefully our discussion clarifies the different types of “tipping point” topics.

		Do the authors think it worthwhile for private or public research, such as at DOE, to seek breakthrough technology that might effectively remove massive amounts of CO2 from the atmosphere? No comment
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Chapter Number	Page Number	Approximate Paragraph Number	Comment or Suggested Edit
	i		In general, criticism and re-analysis of past research is always welcome. This report summarizes some substantial concerns from a small group of researchers. The report should be reframed to reflect this and I provide some suggestions in a later comment. I suspect that simply publishing this report will not offset the hundreds of reports and publications on CO2 and Climate that have come before it. But, new analyses and communication within and outside the research community could make a positive difference, should the findings in this report be substantiated. The DOE Office of Science BER could be provided an opportunity to address the research uncertainties in this document in a thorough and robust manner. Noted.
	iii	1	As someone who used to read the DOE reports on CO2 as a graduate student in the 1990s and then conducted numerous analyses of carbon on many topic areas which were later confirmed by numerous other analyses, it seems somewhat cavalier for DOE to issue one brief conclusive report on the "impacts of carbon dioxide emissions". I suggest the following option: Change the title to "Topics of Uncertainty on the Impacts of Carbon Dioxide Emissions on the U.S. Climate" or " An Assessment of CO2 Impacts on Climate to Guide Future Research ", and then use this report to drive research/analyses for each report chapter which would conclude in separate topical reports that could be finished within a year or two. In doing so, the DOE would positively contribute to addressing some of these standing issues and hopefully enable the nation to move forward in a more productive manner. Noted. New title: "A Critical Assessment of the Impacts of Carbon Dioxide Emissions on U.S. Climate."
	vii	Forward	I appreciate the perspective. It could be useful to add or edit the Secretary's Forward to indicate that "the report has been purposefully commissioned to researchers with alternative perspectives in an effort to address these perspectives and provide some closure for the American public, the US Economy, and US energy policy." I suggest this, because it will be very obvious that a handful of skeptics were chosen out of literally hundreds of extremely active and well-respected scientist. Addressing that upfront will immediately reduce criticism, and hopefully generate a positive environment to address these issues. Everyone would like to see convergence of findings on these issues. Noted. The suggested sentence is not well-phrased, but the reviewer is correct that everyone will see the names and know that the document is coming from a particular perspective. The problem is no such concerns were expressed when people with known biases got put in charge of NCA or IPCC chapters. The path to convergence starts with the wider community admitting that they've been keeping a lid on the necessary discussions. We do not have any control over the Secretary's Foreword
	viii	2	Any increase in greening from additional CO2 will likely be more than offset by longer growing seasons with higher temperatures (i.e., more days over 100). This causes serious risk to the US midwestern "bread basket", which is why this has been considered a national security concern. The data supporting this trend has been published a few times now in Science by a fellow out of Stanford, among others. Sources: Lobell and Field. 2007, doi: 10.1088/1748-9326/2/1/014002; also Sloat et al. 2020, doi:10.1038/s41467-020-15076-4 has a thorough introduction with many citations. The effects, including compound effects, on Agriculture are addressed in Ch 9

	viii	3	My understanding is that the upper bound of emissions (i.e., very high) is business as usual, with no mitigation, and a high-end of growth. It's a worst, yet plausible, case scenario. Similarly, the lowest emissions (i.e., very low) scenario includes technologies that don't yet exist including significant CO2 removal. Both are there to understand plausible extremes. The more likely scenarios are the low to high scenarios. I'm sure researchers are open to revisiting how things are bounded and presented if there are reasonable objections. It seems that within the expert community people are quick to set RCP8.5 aside as a fringe scenario. The problem is it dominates the impacts literature and the media coverage thereof. So the critical discussion herein is needed.
	viii	4	This may be true. But data driven analyses may not capture anticipated feedbacks. They attempt to by design. Limited by data especially ocean heat content, but they take it into account.
	viii	6	I am a big fan of data and meta-analysis. However, I'll note that I do not think forest management practices are overlooked. In fact, it is one of the main driving story lines (i.e., too much fuelwood exists, so we need to harvest more forest). There remains strong debate on the efficacy of fuelwood removal over large areas as an effective means of wildfire reduction. The key to this analysis is to look at whether the extent (not the numbers) of fires has grown and whether the burned areas are returning to forests or returning to brush or grassland. If it's the latter, then that is more likely due to regional changes in climate (temp and precipitation). Again the issue may be what experts discuss among themselves versus what's out there publicly.
	viii	8	I think we can point to sea-level rise in south florida, crop damage, and disease vectors fairly easily. I'm not aware of what costs are associated with these 3 items, but I suspect it's quite large. Dealt with in Ch 11 on economic costs and the SCC.
	viii	9	Yes, this is an important paragraph. Most scientists are not activists. Just because there is a science finding, scientists don't expect that to turn into policy. The public and the democratic system can determine the policy using an evidence-based risk/benefit analysis, just as noted here. Opening up this conversation (which should have been done decades ago) would be welcome and would better engage the public on this issue. DOE could in fact take a leading role here and help address a major national issue. A point of sincere agreement.
1	2		This is all generally correct. I would like to think this is common knowledge. Yes but bears repetition
2	4	1	Why use studies based on satellite sensors? I'm quite sure there are studies (again, out of Stanford) that use historic yield data (county-scale USDA data and global FAO data) with associated temperature and precipitation data. Those analyses do not agree with your findings here, I think. But, we can certainly pose these questions to our scientists that study and develop land models and develop a report based on all available data. I'll also note that for sometime data synthesis wasn't considered fundamental science and was therefore largely ignored. Enabling the researchers to conduct robust data analyses on this and other topics would be largely welcomed. See Ch 9 on Ag effects for the studies on yield data.
2	5	Figure 2.2	All data is interesting and useful for perspective and understanding. But isn't the main question whether we are driving up CO2 and temp at a rapid pace in the post-industrial era? This graph does not help answer that question. Figure 2.2 has been deleted.

2	7	3	Stating that increased aridity in drylands will not lead to decreased productivity seems a bit questionable. We can point to precipitation gradients from high to low precipitation that supports forests to grasslands to shrublands, respectively. Less water in general will mean less productivity; this can be seen in different forest compositions as well. The authors cite Zhang et al. (2014), but Zhang's main point is that the direct CO2 effect may be causing greening in drylands that offsets the decreased precipitation. This may be more specific to dryland vegetation, and Zhang et al. specifically state that this finding is relevant to north-east Brazil, Namibia, western Sahel, Horn of Africa, and central Asia. Zhang 2024, not 2014. The point here is to explain benefits of higher CO2 in terms of crop water productivity. Zhang acknowledges increase in desertification (as we note) but points to a global pattern of greening in arid areas.
2	9	3	I do not disagree with this observation of a decline effect, and I have seen it in some of the early biomass energy analyses that appeared in prominent journals and were then corrected over a few years. While it is unfortunate that some try to grab headlines with unsupported assumptions, it does seem that other researchers tend to provide counter arguments and analyses fairly quickly, indicating that the system does in fact work fairly well. Yes, part of the problem is the later counter-evidence gets relatively little attention, hence this report.
3	19	last	Yes, CO2 uptake by land processes have uncertainty associated with them. It's worth noting that DOE researchers (many of whom are retired now) were world-leading and making progress in this area, but nearly all work on CO2 uptake and emissions stopped 10-15 years ago due to political pressure and political concerns. The Carbon Dioxide Information and Analysis Center at ORNL, now cancelled, was a main contributor to the Global Carbon Project. Now the US is woefully behind and ceding expertise on this to the Europeans (as cited in this report). We are also ceding expertise on carbon monitoring via satellites to other countries. There's nothing necessarily wrong with this if this is where the US wants to go, but it's important to recognize that we have lost significant capacity due to policy changes over many years. We specifically recommend the government increase its focus on basic climate monitoring and data dissemination. The CDIAC was very valuable and we lament its closure.
5	44	1	Some of the early work on this topic was done by researchers at Stanford. But there are plenty of other papers. Here's one that came up in a quick search: https://www.pnas.org/doi/10.1073/pnas.0906865106 We discuss this paper in Ch 9.
5	44	1	Contradicting a number of large meta-analyses on the topic of decreased yields with increased temperature is ok. That's what science is all about. But it's going to have to be done in a more robust way than a couple paragraphs here with one or two citations. This section concerns temperature trends in the corn belt; the discussion of yields is in Ch 9.
6	47	chapter summary	This is very important. I have not dug into the data on extreme storm data (both numbers and intensity). Getting researchers together that disagree on a topic, analyze the data, and publish findings together can be very productive. DOE could sponsor a workshop and bring together a broad range of experts and find answers to extreme weather trends. Good idea

6	47	chapter summary	I conducted some analyses on wildfire years ago. I saw the bias in the university textbooks and in the wildfire working groups, who essentially went by textbook teachings. It was rare that people went back to the original data. The last time I checked the actual data (a good 10 years ago), I found that...you're correct...the number of fires had not changed much. What does seem to be changing is that the extent of fires has grown, and this is mostly attributable to hotter and drier conditions. I do not believe there is more fuel load now than there was before the US was settled. Arguing that harvesting will decrease fire is nonsensical; you have no idea where the lightning is going to strike and subsidizing the thinning of all forest in the western fire zone would be cost prohibitive. I think we need to stop using wildfire management as a justification for harvesting. If we want to harvest more, than do it, and stop using fuel load arguments (which is more of a concept than proven reality) as a reason to do it. The biggest issue here is encroachment of housing communities into the Wild-Urban Interface (WUI) and how we want to handle that with policies. Fire is really only bad if it's burning someone's house down. Otherwise, it's a natural progression in forest dynamics. Sources: Campbell et al. 2012. doi:10.1890/110057.; Schoennagel and Nelson. 2011. doi:10.1890/090199. Excellent comments. It's a big topic we can only glance at but we are trying just to get some pertinent data into the discussion.
6	57	6.3.2	The NCA5 is cited here and elsewhere. However, the USGCRP website that hosts the NCA reports has been removed. Hence, there is no way to read and review the referenced findings. This DOE report is therefore arguing against something that no longer exists, and that may appear questionable. Noted. Out of our control.
7	74	2	Given the satellite observed ice sheet dynamics, I'm not sure that ice sheet retreat is that hypothetical. Our reference is to hypothetical instabilities, i.e. massive disintegration.
7	all		This is the first time I have seen all sea-level rise estimates discredited by an offset from land subsidence. This is certainly a global dynamic that we would want to capture and understand in Earth system models, and DOE can look into this further with analyses and experiments if necessary. Noted.
8	86	all	This and other chapters cite the IPCC AR6. The IPCC provides a global process to address the issues and uncertainties in this report. Perhaps this report can set a path for pivoting research and re-engaging in a useful manner. That's a big ask.
9	104	chapter summary	The last sentence in this summary is not necessarily accurate. The authors cite Ainsworth and Long (2020) with respect to increased CO2 effects on crops. But, Ainsworth and Long (2020) indicate that increased temp and decreased precipitation will have negative impacts on crops, while increased CO2 may offset some of those negative effects. It is the impact of CO2 on climate and the subsequent impact on crops that is the concern; not the direct effect of CO2 on crops. Re written: "U.S. agriculture appears to be robust to current and expected CO2-induced warming."

Chapter Number	Page Number	Approximate Paragraph Number	Comment or Suggested Edit
2	3	2.1.1, para. 2	Zheng not in reference list. Do you mean Zeng? Yes, fixed.
2	3	2.1.1, para. 3	"nearly double"? Why exaggerate? - it's a 76% increase. And they reported that future increase in GPP in extra-tropical northern hemisphere (e.g., U.S.) for [CO2] from 300 to 600 ppm of 42%, or 32% more than previous predictions (not 76%). Replace "nearly double" with "much larger than"
2	3	2.1.1, para.1	Zhu also explained that "other factors (OF) not considered in models, such as forest management, grazing, changes in cultivation practices and varieties, irrigation and disturbances such as storms and insect attacks, can be a cause of mismatch between observed and simulated LAI trends.... OF contributes the most to the observed LAI trend over 25.0% (increase) and 5.3% (decrease) of the vegetated area" We don't claim CO2 is the only factor.
2	3	2.1.1, para.2	This report is meant to focus on the U.S., so it would be more appropriate to discuss greening trends in the U.S. Fig. 2.1 shows that the trend in LAI across much of the U.S., with the exception of the Southeast, is less than the global average. Negative OF effects are mainly found in northern high latitudes (e.g., Alaska). Growing season warmth is the dominant factor in cold regions (10.1038/s41558-018-0258-y). Significant browning also is occurring in parts of Alaska (10.1175/EI-D-20-0025.1) But the effect is still positive. In Ch 9 we discuss US-specific evidence concerning CO2 and crop yields.
2	3	2.1.1, para.2	Greening of the Arctic can have important adverse consequences. Direct observations support that warming and increased vegetation cover in the Boreal-Arctic region showed a "robust increasing trend of CH4 emissions (+8.9%) with strong inter-annual variability. The majority of emission increases occurred in early summer (June and July) and were mainly driven by warming (52.3%) and ecosystem productivity (40.7%)." Yuan et al 2024 (10.1038/s41558-024-01933-3). We don't claim it's good or bad, only that it's been observed.
2	3	2.1.1, para.3	Wang et al 2020 (10.1126/science.abb7772) report a decline over recent decades in CO2 effects on global photosynthesis, possibly due to increasing nutrient interactions or interactions with effects on LAI. It's a controversial finding that attracted skeptical comments in <i>Science</i> regarding the validity of the satellite data and the statistical methods used https://www.science.org/doi/10.1126/science.abg2947 https://www.science.org/doi/10.1126/science.abg4420 https://www.science.org/doi/10.1126/science.abg5673 While the authors in reply defend the satellite data, they acknowledge they may not have dealt adequately with confounding non-CO2 factors. So, it seems premature to invoke this result.

2	4	2.1.2	Much of this information in this section is appropriately covered in chapter 9 on agriculture. Chapter 2 purports to have a wider focus (global and environment responses), so it should not dwell on responses of individual crop plants (crops account for only 15% of global GPP). There has been plenty written on ecosystem response to eCO₂, but evidence such as Fig. 2.3 is not relevant. All analyses of direct eCO₂ effects reveal an overriding interaction with other environmental factors (nitrogen and temperature), and global models show that eCO₂ only partially compensates for the negative effects of climate change on ecosystem carbon response. We struggled with how to divide material up in Ch 2 and Ch 9. The solution we came up with was that here we are addressing direct CO₂ effects, namely CO₂ fertilization; later we discuss Ag effects in more detail. Not everyone paid attention in high school biology. Figure 2.3 serves as an illustration of a point that non-specialists are often surprised to learn, namely that CO₂ is plant food.
2	4	2.1.1, last para.	Zhang, 2025 (10.1016/j.ecolind.2025.113762) reported that although vegetation cover was increasing, resilience against external disturbances (drought, heatwaves, wildfires) has simultaneously declined. They use the lag-1 autocorrelation coefficient as the measure of resilience based on Critical Slowing Down theory. The results are suggestive but very noisy and require a lot of assumptions to equate to a loss of ecosystem resilience. Since the authors also show that vegetation cover is increasing at the same time the results don't appear strong enough to merit any change in our discussion.
2	7	2.1.3, para. 2	Cheng did NOT report "increased plant growth"; they reported increased GPP. The distinction is fundamentally important, has been recognized for decades, and is completely ignored in this chapter. Cheng et al. did refer to an increase in Net Primary Production as well, but you are correct they focused on Gross Primary Production. Sentence rephrased "Similarly, Cheng <i>et al.</i> (2017) noted that increased Gross Primary Production from 1982 to 2011 due to rising..." and GPP be added to the Glossary. More generally since GPP and NPP are closely correlated the use of "plant growth" is suitable.
2	6-7	2.1.3	This material is repeated in chapter 9 where it belongs. Here, it would be more appropriate to focus on how eCO₂ interacts with drought on ecosystem response (e.g., 10.3390/atmos12020212) We tried to avoid repetition but there is some. We discuss drought in Ch 8: since we don't see global and US trends, the issue of declining CO₂ fertilization during droughts isn't a key issue at this point.
3	19	3.2.2, last para.	Regarding the uncertainty in the land sink, a primary reason for this uncertainty is that the primary response of photosynthesis to CO₂ does not predict C sequestration because of strong interactions between CO₂ and climate, nutrients, stand dynamics, and other factors. That is why the almost complete focus in this report on crop plants and plant responses in greenhouses does not inform us about "CO₂ uptake by land processes" We aren't making any strong claims about the land sink, we only report the results in the Global Carbon Project. Not sure if the reviewer is challenging them or not.
9	104	all	This chapter is silent on agricultural effects on atmosphere and climate. Sokal and Kachel 2025 (10.3390/en18092272) conclude: "The current study demonstrated that agricultural activities significantly contribute to the emissions of three main greenhouse gases: carbon dioxide, nitrous oxide, and methane." Emissions from the Ag sector are included in the IAM results discussed in Ch 11.

9	105	9.2, para. 2	The section title is "Field studies..." but the next three paragraphs are primarily about responses of potted plants in growth chambers or greenhouses (with exception of Blandino, which was a field study and showed a much smaller response than the pot studies). There is an important reason that the field data cited in Blandino and in SoyFACE show a smaller response than data from the potted plants under artificial conditions. These data are barely relevant to the topic you are trying to address. FACE plot studies are field studies, and we also discuss other field studies. However we also include some lab experiments. <u>Heading changed to "Field and laboratory studies of CO2 enrichment."</u>
9	105	9.2, para. 3, 4, 5	CO2Science.org website is a highly biased and unreliable website. They report on papers, or specific sentences in papers, that support their view and ignore conflicting reports or qualifying sentences. If there was another site that gathered that much data, we'd cite it. We'd need some evidence of actual bias to disqualify the CO2Science.org archive given the extent of its coverage.
9	105	9.2, para. 3	This is a report for the US. Why are you citing soybean studies in China when there is a major soyFACE study in Illinois? Yield in SoyFACE increased in eCO2 but declined with increasing temperature (10.1093/jxb/erac503). eCO2 did not result in water savings as hypothesized but rather increased soil moisture depletion. (10.1098/rstb.2024.0230) The Chinese study is on point regarding CO2 enrichment. The first study referenced by the reviewer (10.1093/jxb/erac503) only subjected soybean to elevated temperature without varying CO2, so it isn't relevant to our discussion. The second reference is to a general literature survey which doesn't appear to say anything different from what our chapter says.
9	106	9.2, para. 2	Ainsworth et al, 2025 (10.1093/jxb/erac503) state: "Early season stimulation in biomass at elevated [CO2] more than offset lower stomatal conductance in crops, resulting in greater depletion of soil moisture, instead of water savings [30,31]. Wheat tiller survival and grain filling was also reduced by elevated [CO2] under dry conditions [32]. The CO2 fertilization effect was also significantly reduced by growth at elevated temperatures in FACE experiments, again suggesting that high atmospheric [CO2] may not offset the negative impacts of global warming [29]. Thus, it may be that, to date, elevated [CO2] and the resultant climate changes have had net positive effects on agroecosystem productivity, but as climate change intensifies, there will be a shift towards net negative effects as has been suggested for natural ecosystems [3]." Our summary statement on the Ainsworth review is accurate regarding the CO2 effect. They raise the question of compound effects from simultaneous changes in CO2 and temperature. That topic is taken up in the discussion of the NBER study and Section 9.3

9	107	1st para.	Another study that should be cited is Hultgren et al, 2025 (10.1038/s41586-025-09085-w). "For all crops except rice, we estimate that warming will likely reduce global yields by 2050 (probability of loss ranges from 0.701 (sorghum) to 0.946 (wheat))..." "We estimate that global production declines 5.5×10^{14} kcal annually per 1 °C global mean surface temperature (GMST) rise (120 kcal per person per day or 4.4% of recommended consumption per 1 °C; $P < 0.001$). We project that adaptation and income growth alleviate 23% of global losses in 2050 and 34% at the end of the century (6% and 12%, respectively; moderate-emissions scenario), but substantial residual losses remain for all staples except rice." Regions with moderate average temperatures tend to suffer the largest yield losses. "Adjusting for CO2 fertilization does not qualitatively alter the structure of our findings ... but it does reduce the central estimate for end-of-century yield losses by 5.0– 9.5 percentage points... and increases the likelihood of positive aggregate effects." The Hultgren study came out after our draft had been complete. The headline results which generated massive publicity were based on RCP8.5 with no CO2 fertilization. One of our other reviewers wondered why we focused so much on the deficiencies of RCP8.5 when everyone knows it's a marginal case – this study is a good illustration of why. Fig 3 in Hultgren
9	108	1st	Reference to Ziska paper greatly mischaracterizes it. Ziska clearly indicates an effect of eCO2 on nutritional quality, but he indicates there is uncertainty in some of the mechanisms behind that response, including the simple dilution hypothesis. He states up front: "However, it is the direct effect of rising [CO2] on plant chemistry and stoichiometry that represents a continuing threat to the nutritional integrity of both human and animal systems." Ziska doesn't dismiss CO2, but he points out that nutrient dilution has also been observed under historical conditions in which CO2 was likely not the driver. Sentence rephrased "as is the evidence that nutrient dilution observed to date is entirely attributable to higher CO₂"
9	108	9.4, para. 1	Evidence for nutritional decline under eCO2 is widespread: Toreti et al, 2020 10.1038/s43016-020-00195-4) "A meta-analysis of 228 pairs of experimental observations on barley, potato, rice and wheat reported reductions in protein concentrations ranging on average from –15.3% to –9.8% under eCO2, while the reduction was relatively small (–1.4%) in soybean." AND Ainsworth et al 2025: "The positive 'CO2 fertilization' effect on crop yield is complicated by a decrease in many nutrients in elevated [CO2]. An analysis of 130 varieties of plants found that elevated [CO2] decreased the concentration of 25 important minerals by 8% on average, and the carbohydrate to mineral ratio was increased in these plants." We don't dispute any of this; it corresponds with what we say.
9	109		URL for Taylor and Schlenker paper is incorrect. It should be https://www.nber.org/papers/w29320. "papers" not "paper. Was this report peer reviewed? I cannot find it in a peer-reviewed journal. Thanks for the correction. I don't think it has appeared in print anywhere other than the NBER series.

12	129	This chapter is highly distressing, but I suppose it encapsulates the whole thesis of the document. Apparently, there is no point in policies to reduce emissions (or make the necessary changes in energy policy to accomplish emission reductions) because it will make no difference to the atmospheric CO2 concentration or climate. So why bother? Would you have said this in 1970 (CO2= 326), 1990 (CO2 = 354 ppm), or 2010 (CO2=390)? Probably so. And in 30 years when CO2 is 500 ppm, will it be fair to look back and evaluate your apparent call for inaction in the statement here "And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate." But I suppose this attitude is justified if there is no adverse consequence and the only important effect of rising CO2 is to make little plants in greenhouse grow bigger (e.g., Fig. 2.3), and indirect effects on heat stress, drought, fires, sea level, etc. aren't worth discussing. Points taken but the reviewer is calling attention to actual problems finding mitigation strategies with positive net benefits.
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Ch	Page	para	Comment or Suggested Edit
1	2	full text	This chapter points out that the primary concern around human emissions of CO2 is that it changes the radiative balance of the atmosphere. The chapter also makes the points that CO2 has no toxicological effects on humans at current atmospheric levels, and that CO2 is necessary for photosynthesis, with the potential to stimulate plant growth at higher concentrations. These points are well-established scientific facts. Yes and experts know them but non-experts aren't necessarily aware of them.
2	3	3	It would be more reflective of the literature to say here that "Many studies over the past decade have confirmed a global greening pattern (increase in LAI) attributable to rising CO2 levels, changes in climate, changes in nitrogen deposition, land cover change, and other factors." We have added "in part" to sentence.
2	3	3	While the Zhu et al. 2016 study did find that 70.1% (+/- 29.4%) of the integrated global change in LAI was attributable to changes in CO2, most of the observed change in LAI is concentrated in the tropical forest regions of South America, Africa, and Indonesia, as shown in this report's Figure 2.1, reproduced from Zhu et al. In terms of the fraction of global land area influenced most by the factors considered in Zhu et al. 2016, effects on LAI from changing climate is the dominant factor (positive effects for 28.4% of land area plus negative effects on 4.7%, for a total area with dominant climate influence of 33.1%), followed by other factors not represented explicitly in the study or in the models (positive effects on LAI from other factors over 25.0% of land area plus negative effects over 5.3%, for a total area with other factors as the dominant effect of 30.3%), and then CO2 effects (23.2% of land area dominated by positive effects and 0.1% with negative effects, for a total of 23.4%). Since the report is focused on the U.S. it would be helpful to indicate the global context for the numbers reported. We have added new text "Other contributors included land-use changes, warming and nitrogen. The fraction attributable to CO2 was largest in the tropics; other factors played more dominant roles in CONUS."
2	3	3	The dominant factors related to changes in LAI over the U.S. (including Alaska) are land cover change (+LCC), climate effects (+CLI), other factors (+OF and -OF), and then CO2 (+CO2). There are more extensive regions where +CO2 is the dominant factor for the boreal forest zone in Canada. Given that, and given the explicit focus of the report on the U.S., it would be useful to call out in this section that the global greening pattern has distinct geographic variation in driving factors, and that over the target geography of the U.S. it seems to be dominated by factors other than increasing CO2. See my powerpoint slide 1 for a zoom on the area of interest from the Zhu et al. 2016 paper. Addressed with new sentence: CO2 fertilization effects are influenced by local temperature and nutrient and water availability, all of which vary regionally.
2	3	4	"Zheng et al. (2017) confirmed the pattern..." should be modified to say "Zhen et al. (2017) confirmed the pattern of observed greening..." As written, and in the context of the previous paragraph, the current text suggests that Zheng et al. 2017 confirmed the pattern of greening being related mainly to increased CO2, a factor which was not examined in their study. Changed: confirmed the pattern of greening, noting that over thirty years it had added 8 percent...
2	3	4	Without the addition of the appropriate context in the preceeding paragraph (my notes 3, 4, and 5) the remainder of this paragraph could be misinterpreted to mean that the impacts of greening on air temperature are attributable back to a positive effect of CO2 on greening. Rewording has addressed this.

2	3	4	The sentence "Greening has been observed globally but Chen et al. (2019) noted that China and India were exploiting it through land management changes" is misleading. Chen et al. (2019) shows that China and India are <i>causing</i> the observed greening in large areas by intentionally increasing the land area occupied by forests (China) and increases in harvested area in croplands, mainly due to multi-cropping, heavy fertilizer use, and expanded irrigation (China and India). It would be more accurate to say "Greening has been observed globally, but Chen et al. (2019) represent a disproportionate fraction of the total greening trend, accomplished through intentional increases in forest area (China), and expansion of multi-cropping, fertilizer use, and irrigation in croplands (China and India)." Changed: "Greening has been observed globally. Chen et al. (2019) show that in China and India much of it is driven by land management changes"
2	3	3 and 4	Given the changes suggested in these two paragraphs, it raises the question of whether the section title (CO2 and global greening) is itself misleading. That title wrongly suggests that all the content to follow is reflective of a direct influence of CO2 on the observed global greening trends, when the literature presents a much more <i>nuanced</i> interpretation. The changed to CO2 as a contributor to global greening
2	3	3 and 4	It would be worth noting in this section that the multiple remote sensing-based datasets for LAI changes have remarkable differences, especially when comparing the figure 2.1 reproduced from Zhu et al. 2016 with the MODIS-based data record from Chen et al. 2019 (their figure 1). That means it is difficult to place a lot of confidence in the attribution of changes in different regions to different factors. See my powerpoint slide 2 for a comparison of the four datasets used in Zhu et al. 2016 and Chen et al. 2019. Thank you for this information. It is an interesting point but gets into more specialized detail than is necessary for this report.
2	3	5	The authorship for the Haverd et al. 2020 citation is not correct in the References section for this chapter. The correct citation is: Haverd, V., B. Smith, J. G. Canadell, M. Cuntz, S. Mikaloff-Fletcher, G. Farquhar, W. Woodgate, P. R. Briggs and C. M. Trudinger 2020. Higher than expected CO2 fertilization inferred from leaf to global observations. Global Change Biology 26(4): 2390-2402 DOI: https://doi.org/10.1111/gcb.14950. Corrected
2	3	5	A more recent and more comprehensive study (Keenan et al. 2023) reexamined multiple data constraints and concluded that the model used in Haverd et al. 2020 (CABLE) is outside the likely range of CO2 fertilization effects, with higher CO2 fertilization than indicated by multiple independent constraints. At the very least this more recent paper should be cited in the report, with text indicating that the central estimate from the TRENDY models is more likely to be in the range of observational constraints than is the CABLE result. As it stands the report suggests that the latest science indicates that most models have underestimated the fertilization effect, and the literature doesn't currently support that conclusion. See: Keenan, T. F., X. Luo, B. D. Stocker, M. G. De Kauwe, B. E. Medlyn, I. C. Prentice, N. G. Smith, C. Terrer, H. Wang, Y. Zhang and S. Zhou 2023. A constraint on historic growth in global photosynthesis due to rising CO2. Nature Climate Change 13(12): 1376-1381 DOI: 10.1038/s41558-023-01867-2. Added sentence: However Keenan et al (2023) estimated a lower fertilization rate more in line with models.

2	4	1	The attribution analysis in the Chen et al. 2024 paper is very sensitive to the choice of multiple regression vs. partial correlation (their figures 3 vs S7, respectively), and in both cases they seem to misattribute the significant increases in LAI in India and China to CO2 rather than to changes in landcover and cropping practices. This kind of regression-based attribution is less informative than the model-based inference used for example by Zhu et al. 2016. The description of sensor calibration issues in this paper is also very cursory. It would probably be better to refer to the review paper of Piao et al. 2020 to support the claim of continued greening. Piao, S., X. Wang, T. Park, C. Chen, X. Lian, Y. He, J. W. Bjerke, A. Chen, P. Ciais, H. Tømmervik, R. R. Nemani and R. B. Myneni 2020. Characteristics, drivers and feedbacks of global greening. Nature Reviews Earth & Environment 1(1): 14-27 DOI: 10.1038/s43017-019-0001-x. Thank you for the comment. We have taken out the details about the Chen et al. analysis and say simply “Piao et al. (2020) and Chen et al. (2024) report that the greening trend continues with no evidence of slowdown, and CO2 fertilization remains the dominant driver”
2	4	2	The section 2.1.2 (Photosynthesis and CO2 levels) lacks coherence. It seems to be a collection of uncontroversial points about the ability of increased CO2 concentration to stimulate plant growth and reduce water loss through stomates. Figure 2.2 seems intended to show that the current levels of CO2 are not high compared to levels experienced in Earth's deep geologic past. A balanced treatment of the topic might call out the rate of change in CO2 concentration from human-caused emissions, and how both that rate and the absolute levels diverge radically from rates of change and ranges of variability over the past hundreds, thousands, and hundreds of thousands of years. See my powerpoint slide 3 for an example set of figures that might be included. In response to another reviewer, we have added the sentence “While the modern rate of change in CO2 is likely high compared to all prior intervals, the geological evidence is that plants and animals evolved under much higher CO2 levels than at present.”
2	7	4	The report suggests that the topics of CO2 fertilization and increased water use efficiency are not adequately treated in recent IPCC reports. In IPCC's AR6 WG I report there is an entire chapter devoted to an assessment of carbon cycle processes (Chapter 5, Global Carbon and Other Biogeochemical Cycles and Feedbacks). This is precisely where one would expect to find information about CO2 fertilization and water use efficiency. In the Executive Summary for the chapter is the following bolded headline: Increases in atmospheric CO2 lead to increases in land carbon storage through CO2 fertilization of photosynthesis and increased water use efficiency (high confidence). The associated Executive Summary text includes reference to two figures, three chapter sections, and a cross-chapter box all dealing directly with this topic. The Executive Summary text also references the important topic of nutrient dynamics and their interactions with fertilization and ecosystem-climate feedbacks, a critical nuance of the interaction of CO2 and vegetation productivity that is ignored in the report reviewed here. We acknowledge that the topic is addressed in the body of IPCC reports. But we draw attention to its omission from summary documents.

2	8	2	Section 2.2.2 (Coral reef changes) has a strong focus on past examples of early investigations that are later updated. There is also a note about the difficulty of publishing negative results, with a quote that this pattern "is true across all of science". Given the objective of this report, I suggest a shift in tone away from complaints about the kinds of papers that do and don't receive media attention, and instead highlight the latest synthesis of results about the likely future of coral reefs. A relatively recent synthesis paper (Cornwall et al. 2021) in a well-respected journal (PNAS) based on collated data from 233 locations worldwide projects that 37% of reefs will stop accreting and thus fail to keep up with sea level rise by 2050 under the low emissions RCP2.6 scenario, and no reefs would be able to accrete at a rate to stay ahead of sea level rise by 2100 under either RCP4.5 or RCP8.5. This analysis finds that most of the loss of net accretion rate is due to bleaching events, and a minority of the impacts are due to "direct physiological impacts of ocean warming and acidification on calcification or bioerosion". C.E. Cornwall, S. Comeau, N.A. Kornder, C.T. Perry, R. van Hooidek, T.M. DeCarlo, M.S. Pratchett, K.D. Anderson, N. Browne, R. Carpenter, G. Diaz-Pulido, J.P. D'Olivo, S.S. Doo, J. Figueiredo, S.A.V. Fortunato, E. Kennedy, C.A. Lantz, M.T. McCulloch, M. González-Rivero, [...] & R.J. Lowe, Global declines in coral reef calcium carbonate production under ocean acidification and warming, Proc. Natl. Acad. Sci. U.S.A. 118 (21) e2015265118, https://doi.org/10.1073/pnas.2015265118 (2021). This is a model projection study whereas for the very limited purpose of this section we are focusing on current and historical observations.
3	14	1	The study by Connolly et al. 2021 uses a linear regression approach to estimate the amount of variability in surface temperature trends that could be explained by total solar irradiance time series. Their approach is to first model the temperature trend with TSI as the dependent variable, and then compare the residuals from that fit to anthropogenic forcing factors. This is an obviously biased approach, and in fact a full paper was published the following year (in the same journal) laying out the erroneous methods and the faulty conclusions they produce (Richardson and Benestad 2022). Richardson, M. T. and R. E. Benestad 2022. Erroneous use of Statistics behind Claims of a Major Solar Role in Recent Warming. Research in Astronomy and Astrophysics 22(12): 125008 DOI: 10.1088/1674-4527/ac981c. While I agree with R&B that a partial regression is biased unless the regressors are orthogonal, Connolly et al. replied in 2023 at https://iopscience.iop.org/article/10.1088/1674-4527/acf18e in which they used updated AR6 data and reproduced their main result using multiple regression. However they also emphasized that it is only one of many possible results depending on choice of solar proxy and surface T record,
3	18	1	Section 3.2.2 (The carbon cycle relating emissions and concentrations). There is no new information or analysis presented in the chapter, and it relies heavily on Global Carbon Project information. Figure 3.2.3 is described as showing a seven-fold difference in the recent trend in land carbon sink estimates across land models, and this is given as a potential driver of uncertainty in future carbon cycle and climate change predictions. Variation among models is well known and is one of the reasons exercises like CMIP and GCP rely on multi-model ensembles when assessing the state of the science. The distribution of results looks fairly typical in this diagram, with a strong central value around 1.3 to 1.3. We're not claiming to have added new information, just reviewing what's out there.

12	129	3	The following sentence is misleading: "And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate." It is true that bringing global emissions immediately to zero would not reduce CO2 concentrations on short timescales. It is not true that this same scenario means no reduction in human influence on the climate. We must compare the zero emissions scenario to something, and the most meaningful comparison is the current trajectory of increasing emissions and the resulting super-linear increase in concentration. So by reducing emissions to zero we clearly avoid the expected increases in concentration and the expected increases in radiative forcing together with increased near surface air temperature and all the other expected consequences. So our change in action - going to zero emissions - does in fact have an immediate and growing human influence on the trajectory of the climate system. That is not an argument for reducing our emissions to zero tomorrow, it is just an argument for logic and clarity in how we talk about consequences of different actions. The sentence in the text is correct. It's also true to say that going to zero emissions would, over time, open up a widening gap between observed and counterfactual. But realistically we are only looking at marginal changes. The stock-flow mismatch is one reason IAMs have not recommended going to zero emissions.
12	129	5	Regarding the sentence "The practice of referring to unilateral U.S. reductions as "combatting climate change" or "taking action on climate" therefore reflects a profound misunderstanding of the scale of the issue." This makes the dubious assumption that when people refer to "combating climate change" or "taking action on climate" they are ignorant of the scale of the problem. Instead, it is probably more justifiable to assume that it is well-understood by most people who advocate for these local and national changes that the major emitters must act together to make a big difference in global emissions. It is at least worth considering, in the context of this report, that a path toward action at the necessary scale will require local and national action from a broad consortium, and that individual advocacy is a useful and necessary starting point for shifting the inertia of global policies. Sentence modified to read "The practice of referring to unilateral U.S. reductions as "combatting climate change" or "taking action on climate" on the assumption we can stop climate change therefore reflects a profound misunderstanding"

ch	pg	para	Comment or Suggested Edit
Overarching	Overarching	Overarching	• I would like to thank the authors for the opportunity to provide comment on this report. Providing decision-makers with information about the impacts of carbon dioxide emissions on the U.S. climate is critical as they face consequential decisions about the future of energy, agricultural, and environmental policy. Assessments of the science such as IPCC reports and the NCA benefit from undergoing robust review including expert review, public review, and government review with review comments and responses made publicly available. Similarly, important government reports and regulations undergo inter-agency review and are published in the Federal Register for a full notice and comment process and publish a public response to comment. While these processes are far from perfect, they offer the opportunity for improvement and help lend authority to the final products, and I highly encourage you to undertake a similar robust and open peer review process for this report to enhance the report’s credibility in the eyes of decision-makers and the public.
Executive Summary	viii	1	• There is a disconnect between the stated intent of the report by the authors in the preface, “whether carbon dioxide emissions endanger the U.S. public,” and this executive summary, as well as the organization of the report. Would suggest aligning by either reframing the focus in the preface to better match the organization of the report, or better aligning the report organization with the stated focus. Preface has been reworded and the statement eliminated. We have also changed the title to clarify this
Preface	ix	3	• “While the report is intended to be accessible to non-experts, we have omitted some introductory or explanatory material that can easily be accessed elsewhere. Nor have we attempted to survey entire literatures related to the topics covered.” • While this approach is understandable given the time constraints this report was produced under, given the level of visibility this report will have, it potentially opens up the report to criticism of being misleading by omission – focusing on areas where the authors disagree with the broader scientific literature and omitting areas large areas that are known about climate where there is less disagreement. New addition suggested above deals this; also paragraph 2.
Preface	ix	3	• “We have focused as much as possible on literature published since 2020 and referenced previous IPCC and NCA assessment reports. We have also used data through 2024 where possible.” • This is a good approach for this report; however, much of the literature cited is from pre-2020, and many of the references to IPCC and NCA reports are to older reports (e.g. NCA 4 and IPCC AR 4&5) instead of NCA 5 and IPCC reports from the 6th assessment cycle. In these sections that heavily cite this older literature, it is not clear if the newer literature does not address these points or if the issues raised in the older literature are resolved or significantly changed in the newer literature. We have included reference to previous assessment reports where the analysis is insightful and not superseded by later reports. We note that we regard NCA4 as far more credible than NCA5

Preface	ix	3	• The IPCC’s mandate is to assess the scientific literature comprehensively, including a range of views, and report disagreements. This report has a tendency to selectively quote the IPCC focusing on disagreements and excluding areas where scientists agree. This approach risks giving a misleading picture of the state of the science through omission. A possible way to address this is to have a section summarizing areas of agreement by pointing to all statements of fact and high confidence statements from IPCC AR6 before digging into the more controversial areas with disagreement. This could be a short discussion about areas of agreement up front before explaining the focus of this report on these areas of disagreement, with the IPCC statements of fact and high confidence statements included in an appendix. • The report also includes only a very small subset of the literature since 2020. The authors should describe the approach to how they selected the literature included, and if possible, point to any systematic ways excluded literature could lead to different conclusions. • It is also notable that there a fair amount of new analysis in this report done by the authors that has not yet been peer reviewed. It would be good to flag these spots with a note about why these are needed while other related peer reviewed articles are excluded. This is addressed to some extent in the revised Preface
1	2	1	• If the goal of this report is to discuss links between CO2 and climate, this is an odd way to begin the report with a focus on differences between CO2 and criteria air pollutants. It clears up a confusion of language that persists
1	2	1	• “It is an issue of concern because of its potential effects on the global climate, a complex issue that occupies much of this report.” Suggest deleting the word potential as the existence of the effect is not disputed. Deleted: “potential”
1	2	4	• “But the primary concern about CO2 is its role as a greenhouse gas (GHG) that alters the earth’s energy balance.” Would add “warming the planet” to the end of this sentence as the qualitative effect is not debated and the concern is not about the energy balance itself but about the warming effects of the imbalance. Added: “warming the planet”
2	3	1	• “The recent decline in pH is within the range of natural variability on millennial time scales. Most ocean life evolved when the oceans were mildly acidic. Decreasing pH might adversely affect corals, although the Australian Great Barrier Reef has shown considerable growth in recent years.” • Note that the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) finds that pH decline has very likely emerged from natural variability. SROCC SPM A.2.5, “Open ocean surface pH has declined by a very likely range of 0.017–0.027 pH units per decade since the late 1980s, with the decline in surface ocean pH very likely to have already emerged from background natural variability for more than 95% of the ocean surface area.” We have left this out since it relates to attribution, which is beyond the scope of what we are addressing in this chapter
3	15	3	• “Instead, the IPCC has created various sets of scenarios meant to span a plausible range of possibilities” • Suggest changing “created” to “assessed” as the scenarios are created by the science community not the IPCC. We have changed the wording to “used”
3	16	4	• “The IEA trends, which are based on plausible extrapolations of current economic and demographic trends, run below the entire envelope of RCP projections, implying not only that RCP8.5 is dubious, but that even lower emission scenarios are unlikely.” • Burgess compares IEA to the two highest SSP-RCP scenarios, not to the full range. The last sentence of the paragraph is incorrect – the range in Burgess is only no climate policies which doesn’t include the lower RCPs. The Burgess diagram is poorly-labeled and hard to understand. The text has been revised added a reference to Pielke Jr et al 2022 which has a better presentation.
3	17	2	• “As of 2023, global CO2 emissions have been tracking well below SSP7.0 and are even below SSP2-4.5.” • Note that near-term emissions are not necessarily a good predictor of long-term emissions, as the latter will depend on changes in population, demographics, technology, and policy that do not have the same influence on near-term emissions. Noted

3	22	6	• “In summary, while there is clearly warming in the land record, there is also evidence that it is biased upward by patterns of urbanization and that these biases have not been completely removed by the data processing algorithms used to produce climate data sets.” • Quantitative info would be helpful here. How large is the warming? How large might the bias be? This is a topic that needs revisiting. The quantitative estimates are 15+ years old
4	26	1	• The Chapter Summary doesn’t really capture the full tax of the chapter. Would suggest: Defining ECS/TCS, reporting values for ECS and uncertainties/methods, then reporting values for TCS, preferably with a sentence on what those values imply The terms are defined in the chapter
4	26	2	• “This raising of the lower bound is less justified; evidence since the AR6 finds the lower bound of the likely range to be around 1.8°C.” • This isn’t really discussed comprehensively in the chapter. It is discussed, in context of Nic Lewis’ research
4	26	3	• “The climate’s response to increasing concentrations of CO2 is central to the scientific debate on anthropogenic climate change” • Suggest rewording this to, “The magnitude of the climate’s response...” As currently worded it could be a bit misleading since the qualitative effect (i.e. increasing CO2 concentrations lead to increases in global average temperature) is not disputed – the uncertainty is around the magnitude of the effect. Reworded
4	26	6	• The text sites Dayaratna (2016), but this should be a reference to Dayaratna (2017) as listed in the reference section. Fixed
4	26	6	• “If ECS is very high (above 4.5°C) immediate aggressive emission controls become more imperative, whereas no CO2 emission controls are economically justifiable for ECS below 2.0°C (Dayaratna et al. 2016, 2020).” • This could use additional clarification as there are low and now carbon technologies that can be economically justified based on cost of energy alone, depending on technology, location, etc. We have left as is. We are not aware of low or new carbon technologies that are affordable and scalable. Likewise. If energy conservation pays for the low carbon tech people would have been adopting them already.

4	26	6	• “Obtaining a precise estimate is impossible, so policy making needs to account for the uncertainty.” • The Social Cost of CO2 (SC-CO2) as used by the USG in regulatory impact analyses has always accounted for uncertainties in the ECS. EPA (2016) used a probability distribution for the ECS calibrated to IPCC AR4 findings (the most recent values available at the time) to harmonize the approach for the three models used (FUND, DICE, and PAGE). EPA (2023) updated the SC-CO2 in response to NAS recommendations (NAS 2017) to include a much fuller representation of the uncertainties in both ECS and TCR, and utilized a modular approach incorporating the Finite amplitude Impulse Response (FaIR) climate model, a reduced complexity climate model, with ECS and TCR distributions calibrated to IPCC AR6 to represent this uncertainty. • The Dayaratna (2017 & 2020) papers referenced here analyze sensitivity of a subset of the older models used in EPA (2016) to just ECS estimates. It would be helpful to address the advances in the broader literature that are discussed and represented in EPA (2023) as the focus of this report is on literature published since 2020. • EPA (2016) “Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf • NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of Most of the topics are touched upon in Ch 11. The newer EPA approach (e.g. the FaIR model) don’t reflect a fundamentally different approach than before. Will discuss below.
4	28	2	• “Because of concerns about model tuning and the high sensitivity to cloud parameterizations, the IPCC AR6 (2021) did not rely on climate model simulations in their assessment of climate sensitivity, relying instead on data-driven methods.” • AR6 WGI 7.5.5 states this a little differently. IPCC’s assessment wasn’t “directly informed” but “ESMs remain essential tools.” Our statement is ok as is
4	29	3	• “For AR6, the IPCC placed primary weight on the results of Sherwood et al. (2020)...” • The IPCC assessed a large number of studies, not just Sherwood (2020). Our statement is ok as is. Sherwood et al was predominantly relied upon
5	32	1	• It would be helpful for the reader for this chapter to start with a summary figure (e.g. like IPCC AR6 WG1 – SPM.1 or Fig. 3.4). Currently, the chapter jumps right into details that will be difficult for anyone who is not a climate scientist or already versed in these issues to understand or interpret. Too late in the process to add a new figure
5	33	Figure	• “Figure 5.1 CMIP6 Average surface temperature range across 33 models and standard deviation using SSP5-85 scenario.” • SSP5-85 is an excessively high scenario that is not representative of current expectations of emissions projections. Suggest changing the figure for on with data from a less misleading and more representative scenario. The use of 8.5 doesnt make much difference given high spread for historical period, but we agree this should be changed for a subsequent version of the Report

5	34	1	• There have been extensive published comments and responses on the approach used in Scafetta (2023). Can these be reflected here? • G.A. Schmidt, G.S. Jones, and J.J. Kennedy, "Comment on "Advanced Testing of Low, Medium, and High ECS CMIP6 GCM Simulations Versus ERA5-T2m" by N. Scafetta (2022)", Geophysical Research Letters, vol. 50, 2023. http://dx.doi.org/10.1029/2022GL102530 • N. Scafetta, "Reply to "Comment on 'Advanced Testing of Low, Medium, and High ECS CMIP6 GCM Simulations Versus ERA5-T2m' by N. Scafetta (2022)" by Schmidt et al. (2023)", Geophysical Research Letters, vol. 50, 2023. http://dx.doi.org/10.1029/2023GL104960 • Z. Hausfather, K. Marvel, G.A. Schmidt, J.W. Nielsen-Gammon, and M. Zelinka, "Climate simulations: recognize the 'hot model' problem", Nature, vol. 605, pp. 26-29, 2022. http://dx.doi.org/10.1038/d41586-022-01192-2 • S. Jain, A.A. Scaife, T.G. Shepherd, C. Deser, N. Dunstone, G.A. Schmidt, K.E. Trenberth, and T. Turkington, "Importance of internal variability for climate model assessment", npj Climate and Atmospheric Science, vol. 6, 2023. http://dx.doi.org/10.1038/s41612-023-00389-0 The Schmidt et al paper is a comment on a different paper of Scafetta's and focuses on his t-statistic, which isn't pertinent to the paper we cite (from Climate Dynamics). Regarding the Jain et al paper, Scafetta uses ensemble ranges within each ECS type and doesn't simply rule models out but shows that some perform well for TAS. Relevance of the Hausfather et al paper is not clear.
5	34	4	• "Spencer (2024) has also provided a useful summary of the Model-Observation mismatch by comparing trends in surface temperature data products with those in individual climate models, as summarized in Figure 5.3; most climate models show substantially more warming than the observations since 1979." • It is worth noting that IPCC projected temperatures do not use all models and instead focus on those that best reproduce observations. So while some models may show warmer or cooler temperatures than observations, that does not imply that projections from large assessments reflect those biases. Our text speaks to the collection of CMIP6 climate models; some of those with the largest amount of warming are widely used models from the US and UK
5	37	3	• "Hence, we assess with medium confidence that CMIP5 and CMIP6 models continue to overestimate observed warming in the upper tropical troposphere over the 1979–2014 period by at least 0.1°C per decade," • "Notably, despite the accumulation of evidence of excess model warming the IPCC assigns only medium confidence to the existence of a warming bias." • This reflects a more general issue with IPCC confidence statements where the inclusion of a quantification reduces the confidence they include. Here the full statement with the quantification of 0.1C per decade is assigned medium confidence whereas a statement about the existence of the bias without a specific quantification would receive higher confidence. Noted
5	39	Figure 5.7	• Does this update with data through 2024 use the same models that Christy and McNider (2017) used, or does it use updated versions for the models as well? This would be helpful to clarify here and in other places where figures are produced with updated data. Excellent catch. Fig. 5.7 uses CMIP-6 models, this should be stated in the caption as an update of Christy and McNider with CMIP6 output. Change made
5	39	3	• "The IPCC AR6 did not assess this issue." • Was this assessed in IPCC AR5? Many of the citations here could have been assessed then. Is there any more recent evidence on these issues that should be referenced here? IPCC has never addressed this issue with rigor, but does reluctantly notes the discrepancy. I don't think AR5 assessed the amplification discrepancy except maybe to dismiss it. But AR6 should have in any case.
5	40	1	• Are there more recent papers or data available? All the info here is AR6 or pre-AR6, but more recent years have shown more surface warming. It would be interesting to show stratospheric temperatures for these more recent years as well to see how this relationship holds. Santer et al. (2025) has been added.

5	40	5	• Trends in snow cover depend on both changes in precipitation and changes in temperature. It would be helpful if these were discussed separately rather than showing the net effect for one region/season. Context for statement is that the models get it wrong
6	47	1	• This chapter relies solely on observations and does not include other lines of evidence, it would be helpful to discuss what these other lines of evidence indicate to avoid introducing potential biases (e.g. what do process based lines of evidence show?) Yes we rely primarily on observations. We have added some text regarding process-based analyses, notably in the section on hurricanes
6	47	1	• The chapter summary does not fully capture the chapter or the science. Suggest talking about the extremes affected by climate, the extremes not affected by climate, and those where the data isn't sufficient to establish a trend. We think our summary is appropriate
6	47	3	• “Over geologic time the climate system has generated an (essentially) infinite variety of weather patterns and extremes...” • Just because an event occurred before humans does not mean humans are not influencing the frequency or intensity of such events now. Additionally, if something has happened in the geologic record, but humans have never experienced it before, they may not be prepared for such an event. OK, but that has nothing to do with CO2. Adaptation to extreme weather is a separate but important issue
6	50	Figure	• The figure heading has “@RyanMaue” in the title. Looks odd to have a social media handle in the figure. Is the source peer reviewed? We have added reference to an older publication by Maue that describes the analysis
6	52	4	• Insufficient data is different than no effects. It would be helpful to be clear in instances like this whether a conclusion is because the data supports it, or because there is insufficient data to say the opposite. This is covered in the last para of the section
6	53	Table	• Could you also show a similar table with hurricane precipitation? Not in this round. Very hard to get historical rainfall going very far back
6	53	5	• The last two paragraphs show findings from NCA4. With the interest in focusing on recent literature, what does NCA5 say about these issues? Does it not cover this issue, does it say the same thing, does it contradict this finding? NCA5 statements are discussed in the body of the text, see pp 57ff.
6	54	1	• The heading of section 6.3.1 is a bit misleading as this is partly driven by warmer winters and fewer cold days. For the CONUS, the heading is accurate as demonstrated with observational analyses
6	58	Figure	• Figure 6.3.5 shows the number of days greater than or equal to 95F in 6-year periods. Why show this in 6-year periods? That seems like an unusual choice. Would this look different with 5, 10, or 15 year periods? The time series is 126 years long, which is evenly divisible by 6. The point is to compress the depiction of interannual (i.e. natural) variability and examine slower changes. In our decimal system, 5 or 10 years is more commonly used, but with 126 years of data, we did not want to leave an “orphan” column (one with fewer years) compared with the entire time series. Explained in the Figure caption
6	58	4	• “We measure “Heatwave Days” here as the count of all days in May-Sep each year that exceed the 90th percentile for that day and that lie within a period of at least six consecutive days.” • Why six consecutive days? Would this look different for 5 days, a week, 10 days? Six days seems like an unusual period to pick. As noted in the text we use a metric defined in NCA4 for heat wave days. Regardless, whatever parametric choice is made (i.e. 5 days, 10 days, 85th percentile, etc.) the 1920s to early 1950s dominate the occurrence of heat wave days.

			Added: The pattern of results show below does not depend on the choice of reference period.)”
6	58	4	• The dependence on and subsequent choice of reference periods is worrying. Can multiple reference periods be shown to show the dependence? There will be no change in the fundamental result no matter which reference period is chosen. If the entire period-of-record is used to calculate percentiles, there will be fewer percentile exceedences than if a cold reference period is chosen (as was done in NCA4). However, the shape of the outcome will be the same.
6	59	3	• “The NCA5 directs readers to the website https://www.globalchange.gov/indicators/heat-waves (USGCRP 2023)” • Broken link. The link was live when the report was written, but the Reviewer is correct that it is now broken. Fortunately, we included the figure from that link to demonstrate the unusual start date (1961) and the fact that the sample contained only large cities.
6	61	3 to 6	• This reads as a very selective analysis. With a very tight time constraint and the fact our analysis required the construction of serially complete datasets, we selected regions that were called out by NCA5 and/or the IPCC AR6 as unusual. In future versions we shall have more regions to examine (e.g. upper Midwest, Central Plains, Texas Hill Country).
6	67	2	• Is this section suggesting that climate change is causing the decrease in tornadoes? No, this section doesn’t engage in attribution
6	68	7	• This is another place where it would be better to reference newer literature and NCA5 instead of relying on NCA4. What has changed since then? NCA5 mentions drought many times, but in anecdotal ways without metrics for testing. For example, NCA5 pg 1-23 states. <i>“Between 1980 and 2022, drought and related heatwaves caused approximately \$328 Billion in damages (in 2022 dollars). Recent droughts have strained surface water and groundwater supplies, reduced agricultural productivity, and lowered water levels in major reservoirs, threatening hydropower generation.”</i> This statement simply says that the demand for water was not met by the human-built systems which manage water supplies – there is no metric here that measures a change in the natural water supply. The statements on which we focus relate to whether the supply has been changing – a metric related to the climate system.
6	69	1	• Figure 6.7.1, is this the same indicator used in AR6? We have clarified the text to refer to meteorological drought. AR6 speaks mostly of “Agricultural and Ecological Droughts” which are defined in for various regions as <i>“Agricultural and ecological droughts are assessed based on observed and simulated changes in total column soil moisture, complemented by evidence on changes in surface soil moisture, water balance (precipitation minus evapotranspiration) and indices driven by precipitation and atmospheric evaporative demand”</i>., so we are unsure what specific metric is referenced.” Elsewhere it simply uses the term “drought” or “Meteorological and Hydrological Drought.” AR6 pg 1075 “A drought is a period of abnormally dry weather that persists for long enough to cause a serious hydrological imbalance (Glossary; Wilhite and Glantz, 1985; Wilhite, 2000; Cook et al., 2018). Most droughts begin as persistent precipitation deficits (‘meteorological drought’) that propagate over time into deficits in soil moisture, streamflow, and water storage (Figure 8.6), leading to a reduction in water supply (‘hydrological drought’). Increased atmospheric evaporative demand increases plant water stress, leading to ‘agricultural and ecological drought’.

			The best we can say is the AR6 used a different metric than shown in Fig. 6.7.1 that likely varied from region to region. However, Fig. 6.7.1 has high correspondence with drought-related impacts.
6	69	3	• “In summary there is no evidence of increasing drought frequency or intensity in the U.S. or globally over recent decades.” • This statement is not supported by the citations presented here. AR6 finds that there are trends in agricultural and ecological droughts and this section does not contradict that finding, so this general statement about there being no evidence of increasing drought frequency or intensity is misleading. • AR6 SPM A.3.2 – “Human-induced climate change has contributed to increases in agricultural and ecological droughts in some regions due to increased land evapotranspiration (medium confidence).” Footnote, “Agricultural and ecological drought (depending on the affected biome): a period with abnormal soil moisture deficit, which results from combined shortage of precipitation and excess evapotranspiration, and during the growing season impinges on crop production or ecosystem function in general (see Annex VII: Glossary). Observed changes in meteorological droughts (precipitation deficits) and hydrological droughts (streamflow deficits) are distinct from those in agricultural and ecological droughts and are addressed in the underlying AR6 material (Chapter 11).” We have added “meteorological” to last sentence
6	69	4	• “The IPCC has not provided an assessment of wildfires.” • AR6 WGII SPM discusses wildfire, and WG1 SPM discusses fire weather. • AR6 WGII SPM – B.1.1, B.1.4, Fig. SPM.2, Fig. SPM.3, B.5.2, B.6.2, C.2.3, C.4.2, D.4.2, • AR6 WGI SPM – C.2.4 Restated: The IPCC has not provided an attribution analysis of wildfires
7	75	1	• “The largest sea level increases along U.S. coasts are Galveston, New Orleans, and the Chesapeake Bay regions” • How much? Are there quantifications? The figures show this
8	83	3	• “AR5 Working Group II (Cramer et al., 2014) makes the following statement:” • What does AR6 say on this topic? The science on attribution has evolved since AR5. The AR6 did not make an analogous statement, but the challenges haven’t been resolved
8	84	6	• “There are three areas of substantive criticism of the IPCC’s assessment of the causes of the recent warming...” • Are there citations that can be included here or are these criticisms attributed to the authors? The section describes this adequately
8	84	6	• “IPCC’s policy-informing...” • This phrasing is a bit odd. IPCC reports are policy relevant but policy neutral. This phrasing the direct policy in some way. Deleted policy-informing
8	90	3	• “For comparison, the IPCC estimate of forcing from the increase in atmospheric CO2 compared to preindustrial times is approximately 2.2 W/m2 (Figure 3.1.2).” • This is comparing different time periods. Figure 8.2 includes data for 2023 and 2024, IPCC wouldn’t include the most recent years since it was published in 2021. Suggest updating from the IPCC data to Forster et al. (2024) that updates these indicators. • Forster et al. (2024) “Indicators of Global Climate Change 2024: annual update of key indicators of the state of the climate system and human influence” https://doi.org/10.5194/essd-17-2641-2025 Updated
8	92	2	• “It is not easy to justify a new positive low cloud feedback that began emerging in 2015.” • Explain why this is not easy? Added, “since there is no obvious feedback trigger starting in 2015” e

8	93	4	• “Other columns of IPCC Table 12.12 report on whether anthropogenic signals are expected to emerge this century under RCP8.5, the most extreme forcing scenario. We have omitted these columns for several reasons.” • Can this be done for RCPs other than 8.5? The point of these omitted columns in IPCC Table 12.12 was to show that for some extremes we may not see an effect now, but will in the future. As it is presented here it implies future changes won’t matter. Agree 4.5 would have been better, but this is a query that should be directed to the IPCC
9	104	1	• IPCC AR6 WGII has an assessment of agriculture (both in the SPM and in Chapter 5), and the IPCC also has a special report on Climate Change and Land, that are more comprehensive, recent, and cover a larger range of the literature than discussed here. Please update this chapter to reflect these findings. Need a more specific point of challenge. Other reviewers have brought up specific topics that were either addressed by revisions or are already covered. I think this is one area that goes under the heading of critiquing the mainstream, based on peer-reviewed literature.
10	110	4	• Section 10.1 rightly points out that technological advances have substantially reduced losses from extreme weather events. We are better at forecasting, preparing for, and adapting to extreme weather than we were in the past, and these advances all help reduce impacts. However, our ability to do this in the future depends upon preparing for future changes – we can’t simply assume adaptation will continue, we need to provide information on future risks and how those risks are impacted by climate change in order to inform continued technological advances and future adaptation. Noted
10	111	1	• “In May 2025 NOAA announced it has withdrawn the Billion Dollar Disaster product from publication (Pielke Jr., 2025).” • It would be better to cite an official government source from NOAA announcing this withdraw instead of a blog post commenting on it. Agreed, but this is the best information available from a well-published expert
10	111	2	• Losses from extreme weather and climate events are driven by climate risk (the physical events themselves), exposure to those risks (population and infrastructure impacted by these events), and adaptation to those events (technological advances in forecasting, warning systems, and resiliency). Understanding these risks requires disentangling these drivers in order to prepare for the future. Noted. Such a risk assessment is beyond the scope of this report
10	112	1	• There are additional citations that focus on the net effects of heat and cold related mortality that would be worth discussing and citing in this section. • EPA. 2024. Draft Technical Documentation for the Framework for Evaluating Damages and Impacts (FrEDI). U.S. Environmental Protection Agency, EPA 430-R-24-001. • Cromar et al., 2022. Global Health Impacts for Economic Models of Climate Change: A Systematic Review and Meta-Analysis. Ann. Am. Thorac. Soc. 19, 1203–1212. https://doi.org/10.1513/AnnalsATS.202110-1193OC • Hsiang et al., 2017. Estimating economic damage from climate change in the United States. Science 356, 1362–1369. • Mills et al., 2015. Climate change impacts on extreme temperature mortality in select metropolitan areas in the United States. Clim. Change 131, 83–95 The Cromar meta-analysis included only 7 studies for the US all published before 2015, and not all of them examined both hot and cold extremes. We think the citations we have, which includes the EPA, are adequate.
10	113	7	• Section 10.3.2 has good points about the importance of energy affordability and how energy poverty impacts adaptation behaviors. Cong et al. (2022) is another good citation for this section. • Cong, S., Nock, D., Qiu, Y.L. et al. Unveiling hidden energy poverty using the energy equity gap. Nat Commun 13, 2456 (2022). https://doi.org/10.1038/s41467-022-30146-5 Citation added

11	Chapter	Chapter	• Much of this chapter if focused on older literature on SCC and on applications that fall outside of how the USG has actually implemented SCC. This chapter would benefit from a more explicit focus on EPA (2023) as it represents the latest state of the literature on SCC, shows how the USG applies the SCC for regulatory impact analyses, shows how the USG updated the older IAG era SCC as represented in EPA (2016) in response to the recommendations in NAS (2017), shows how uncertainty is incorporated into SCC estimates, and discusses areas of the literature that are on the frontier, highly uncertain, and not ready to be incorporated into the official USG estimates. • As currently written much of this chapter is focused on these highly uncertain areas of the literature that are not incorporated into USG SCC estimates (e.g. tipping points, and climate change impacts on economic growth). EPA (2023) discusses these issues and why they are not ready to be incorporated into the official estimates. • Furthermore, EPA (2023) estimates of the SC-GHG does incorporate climate benefits such as CO2 fertilization and reductions in cold mortality discussed elsewhere in this report, and this should be noted and discussed. • Finally, this section ignores areas of real controversy in the calculation of SC-GHG as it is used by the USG – namely the question of global vs. domestic benefits and the treatment of discounting when valuing benefits to future generations. These controversial issues deserve far more attention in this report instead of spending so much space on issues on the fringe of the literature that are not even included in USG SC-GHG estimates. • EPA (2016) “Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf • NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of The new discussion by the EPA simply rehashes longstanding issues. Switching to separable models like FaIR isn’t an advance, because everything still comes down to choice of ECS, discount rate, etc. They add some new damage components but as discussed they jumped on the M17 findings prematurely. Ch 11 focuses a lot on non-SCC topics like the relationship between temperature and growth because that’s been the focus of a lot of research. It’s not the case that this work is too new to be incorporated into SCC calculations. Moore and Diaz (cited) for example incorporated the Dell et al result into an SCC model. The problem is that the temperature signal in growth isn’t robust so economists aren’t convinced it belongs in the models. We don’t discuss the global vs local benefits issue mainly because standard SCC models have always assumed we should measure global effects and we are not offering an argument otherwise.
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11	116-120	Section 11.1	• This chapter has a heavy focus on the relation between climate change and economic growth and how this relationship factors into the SCC. There is an ongoing debate in the literature about persistence in climate damages as measured by changes in economic growth over time; however, these persistence effects on economic growth are not considered in the most recent version of the SC-GHG used by the USG – EPA (2023). This chapter generally ignores the existence of EPA (2023), it is mentioned once in passing, and does not inform readers that these controversial areas of current research are not included in government estimates of the SC-GHG. • EPA (2023) page 58 says, “Given the statistical insignificance of the estimated coefficient on the productivity indicator in the published Howard and Sterner meta-analysis, the SC-GHG estimates presented in this report do not rely on Howard and Sterner’s specifications that include productivity effects. This is consistent with the authors’ recommendations in the published paper, to only consider the inclusion of the productivity impact in sensitivity analysis. However, the question of whether the effects of climate change impacts (e.g., temperature, tropical cyclones, and other extreme weather events) on the economy are only temporary or persistent is an active area of research. Over the past decade, a host of empirical studies have found evidence of temperature changes having persistent effects on the economy (e.g., Dell et al. 2012; Burke et al. 2015; Moore and Diaz 2015; Deryugina and Hsiang 2017; Ricke et al. 2018; Burke and Tanutama 2019; Colacito et al. 2019; Henseler and Schumacher 2019; Kahn et al. 2021; Kumar and Khanna 2019; Bastien-Olvera et al. 2022); this is an important finding because even small changes in economic growth rates accumulate into large economic impacts over time.” Some are discussed in Section 11.1.2 but McKittrick’s review is more up to date.
11	116	1	• “Economists have long considered climate a relatively unimportant factor in economic growth, a view echoed by the IPCC itself in AR5.” • It would be good to update this to the relevant conclusions in AR6 to reflect the more recent literature. AR6 didn’t have an economics chapter comparable to AR5.
11	117	5	• This section makes an important point, much of the public does not understand that climate impacts are relative to projected future without climate change and need to be put in the context of economic growth and a future where our decedents are better off than we are today. O’Neill (2023) is a useful citation here, finding that, “Climate change research and assessments, including the most recent IPCC report, paint an increasingly dire picture of the future. However, the assumption that the future will be worse than the present may be wrong for many aspects of human well-being.” • O’Neill, B.C. Envisioning a future with climate change. Nat. Clim. Chang. 13, 874–876 (2023). https://doi.org/10.1038/s41558-023-01784-4 Citation added
11	119	3	• “Overall they could not detect a temperature effect on GDP or GDP growth, and they estimated the 95 percent confidence interval for the impact on global growth as of 2100 even under the exaggerated RCP8.5 warming scenario spans .86 percent to +388 percent. In other words the net effect is likely positive but too uncertain to distinguish from zero.” • This finding from Newell et al. (2021) needs to be contextualized with their complementary finding that models excluding growth effects and relating temperatures to GDP levels are far more certain. This is important to include since the actual USG application of SC-GHG does not include growth effects. • Newell et al. (20201) states, “Models relating temperature to GDP levels yield climate impact estimates that are far more certain. The best such models imply GDP losses by 2100 of 1–3%, consistent with damage functions currently embedded in the major integrated assessment models that underpin the U.S. social cost of carbon.” The discussion in this section is focused on the effect of dT on growth. The discussion of how dT affects the level of income is what 11.1.1 focuses on. It’s very regionally heterogenous so the small global average reported in Newell et al. isn’t very insightful.
11	119	6	• “To summarize, economists consider climate a relatively unimportant factor in economic growth, a view echoed by the IPCC itself in the Fifth Assessment Report.” • Need to update to reflect AR6 findings. See above

11	121		• “The concepts of estimation and uncertainty do not readily apply to SCC calculations.” • The discussion of uncertainty in IAMs should reflect EPA (2023) which incorporated many major advances in the treatment of uncertainty in integrated assessment modeling. See section A.8 of EPA (2023) for a summary of the quantified sources of uncertainty in the SCGHG estimates presented in EPA (2023) • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf Our point is that the key underlying parameters are uncertain, and the range of SCC estimates merely reflects those uncertainties. The fact that the EPA proposes ways to compute distributions of the SCC doesn’t affect this point, it follows from it.
11	121	3	• “Economists use IAMs to compute the SCC. Two of the best known are the Climate Framework for Uncertainty, Negotiation and Distribution (“FUND”, Tol 1997) and Nordhaus’ DICE.” • This is old literature. Given the advances since FUND and DICE were the leading SCC models, and this report’s focus on literature post-2020, this section should be updated to focus on the models used to calculate the SC-GHG in EPA (2023) which represents advances over the approach used in FUND and DICE in response to NAS (2017) recommendations. Added a mention of this. • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf
11	121	4	• “and a ‘judgmental adjustment’ of 0.5 percent for excluded impacts at 3°C warming” • EPA (2023) is the most up to date representation of the USG approach to SC-GHG incorporating the recommendations of the NAS (2017), and EPA (2023) explicitly does not included an adder for missing damages. This is another example of this chapter focusing on older less relevant literature, and it really should be comprehensively updated to address EPA (2023). Barrage and Nordhaus is a (2024) paper. We don’t endorse their approach, just describe it. But in some respects the EPA approach is already obsolete because the new Administration has abolished the SCC. • EPA (2023), page 59 states, “the model runs performed for this report do not adopt a 25% adder (as used in the DICE model (e.g., Nordhaus 2017)) to account for unknown or missing damages for the meta-analysis-based damage module.” • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. • NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of

11	122	6	• “Abatement costs: IAMs represent the cost to the economy of reducing CO2 emissions. If CO2 emission reductions are assumed to be inexpensive, then the model will conclude that the optimal policy should aim for deeper emission cuts and vice versa.” • IAMs such as DICE are often used in a mode of calculating the optimal level of abatement where they do indeed compare the SCC with the marginal cost of abatement to find the optimum. However, these abatement costs are not part of the SCC calculation, and as used by the USG for the purpose of regulatory impact analyses, this feature of these IAMs is not used. Instead the USG has other more appropriate tools for analyzing the costs of specific regulations. This distinction is important here as the assumptions about the cost of emissions abatement does not have any bearing on the calculation of the SCC. The paragraph has been rewritten to clarify this.
11	122	7	• “For example, in 2023 the U.S. Environmental Protection Agency raised its preferred SCC value about 5-fold over the estimates it had issued ten years earlier. This is not because new data had been collected or better mathematical methods had been invented, but because new assumptions had been used, and the validity of those assumptions was a separate question.” • This paragraph contains the only reference to EPA (2023). First, the characterization of this update as only because new assumptions are used is factually incorrect. EPA (2023) represents a significant change to how the USG calculated the SC-GHG moving away from the FUND/DICE/PAGE models used in the IWG era (see EPA (2016)) to a modular approach as recommended by NAS (2017). This chapter needs to address the NAS (2017) recommendations and the EPA (2023) response to those recommendations to capture how SC-GHG was actually used by the USG and how the literature has evolved over time. The tabulations in EPA 2023 p. 81 show that if they had not changed the Ag productivity assumption and added a large mortality cost they’d have ended up with SCC numbers very close to the 2013 IWG numbers. Assuming very low discount rates did the rest. Using the FaIR model with the DSCIM and GIVE damage modules wasn’t the key change, it was • EPA (2016) “Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf • EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf § NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of
11	123	2	• “It should also be noted that the SCC is focused on the social costs of CO2 emissions from fossil fuel use. It does not measure the private marginal benefits to consumers and society from the availability of fossil fuels. Public willingness to pay for fuels of all types indicates the value to society of reliable, abundant fossil energy.” • Two points to make about this section. First, the benefits to society generally accrue from the provision of energy services, not from specific fuels.” A distinction without a difference in this context. Second, the private marginal benefit of the availability of fossil fuels or energy services is not part of the SCC because changes in the cost and provision of the energy services should be part of the other side of the cost benefit analysis. The SCC is used to characterize the benefits of GHG emissions abatement, and the changes in the costs and availability of energy services are part of the cost of emissions abatement. Agreed, changed the wording to clarify
11	125	5	• “the uncertainty of SCC estimates doesn’t mean that other regulatory measures are inherently better or more efficient.” • ‘regulatory measures’ is a poor word choice here as it can be confused with the regulation itself instead of the metric used to assess the regulation. Changed measures to instruments

11	123-125	Section 11.1	• Section 11.2.4 has an interesting discussion of tipping points. This is an active area of research in the field, however it needs to be noted that tipping points or tipping elements are not included in the SC-GHG as used by the USG, see EPA (2023). • EPA (2023), page 3 says, “For example, the modeling in this report omits most of the consequences of changes in precipitation, damages from extreme weather events, the potential for nongradual damages from passing critical thresholds (e.g., tipping elements) in natural or socioeconomic systems, and nonclimate mediated effects of GHG emissions other than CO2 fertilization (e.g., ocean acidification due to CO2 emissions, tropospheric ozone formation due to CH4 emissions). Importantly, this update does not yet reflect interaction effects and feedback effects within, and across, natural and human systems. For example, it does not explicitly reflect potential interactions among damage categories, such as those stemming from the interdependencies of energy, water, and land use. These interactions and feedbacks, and others, were highlighted by the National Academies as an important area of future research for longer-term enhancements in the SC-GHG estimation framework.” Not necessary to say this since EPA is on hold from doing SCC calculations
12	129	1	• This chapter summary is misleading as it is describing change from today’s temperature rather than the effect on future temperatures. A change from today’s temperature is the future temperature. Not sure what the objection is.
12	129	2	• “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate.” • If global emissions were to go to zero tomorrow, CO2 concentrations would stabilize, and global temperature would be approximately constant. Net negative CO2 would result in reductions of concentrations and temperatures. In other words, while reducing global CO2 emissions to zero might not lead to near-term reductions in CO2 concentrations from today’s levels, it would stop future increases in CO2 concentrations. Consistent with what we stated.
12	129	3	• This section is focused on unilateral action, but needs to address questions related to collective action and individual actions by multiple parties when the benefits of abatement and the damages from emissions have extensive externalities. • Kotchen (2021) provides a theoretical perspective on the global vs. domestic SCC question and addresses questions related to how an individual country’s decisions are impacted by the expected choices of other countries given that GHG emissions are globally mixed the benefits of GHG abatement are shared widely. • Kotchen (2021). Which Social Cost of Carbon? A Theoretical Perspective. Journal of the Association of Environmental and Resource Economists. https://doi.org/10.1086/697241 An interesting line of thought but we can’t get into game theoretic models here.
12	129	4	• “Since that rate has been averaging about 50 percent of emissions in recent decades, a reduction of global emissions by 50 percent would (at least temporarily) halt the rise in atmospheric CO2.” • This may be addressed in earlier chapters that this reviewer has not read yet, but the standard framing is that stabilizing CO2 concentrations requires balancing emissions by sources and removals by sinks. Removals by sinks includes both natural sequestration and anthropogenic sequestration (e.g. afforestation if it can be done that increases the overall land sink removal, or direct air capture). It could be useful to clarify this here. The discussion is only an approximation for illustrative purposes
12	129	5	• “Lomborg (2016) estimated that full compliance with the Paris Accord would not stop warming, it would only prevent about 0.1C warming and delay hitting the baseline year 2100 temperature levels by about a decade.” • Note that the Lomborg (2016) finding is related to, “the of impact of the total, global emission cuts implied by all the submitted INDCs,” this is different than ‘full compliance with the Paris Accord’ as the INDCs analyzed in the paper are only the first round of Intended Nationally Determined Contributions submitted ahead of COP-21, and the Paris Accord requires additional Nationally Determined Contributions every 5 years. Since Lomborg (2016) only analyzes these INDCs, and parties have submitted two rounds of NDCs since then, suggest changing the wording here to, “... full compliance with initial commitments submitted ahead of the Paris Accord.” Changed.

12	129	Chapter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is PART 1] • Section 12.1 is titled, “The scale of the problem,” is framed around contrasting criteria air contaminants with CO2 emissions; however, there really are three separate issues that need to be disentangled: Stock vs. Flow. • The challenge here is that abatement costs borne by people today benefit people in the future – temporal externalities. • CO2 emissions are a stock pollutant, so impacts depend on the cumulative emissions to date, whereas traditional criteria are a flow pollutant and impacts depend on the emissions at that point in time. Emissions of a stock pollutant going to zero will not affect impacts at that point in time, as the stock remains unchanged, but will have large impacts in the future as the stock will cease to increase until emissions resume; whereas emissions of a flow pollutant going to zero will immediately eliminate impacts, but impacts will have no lasting effects on future impacts as they will immediately resume when emissions resume. • The sentence at the end of the second paragraph of this section reads, “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate.” This is conflating the expectations of how stock and flow pollutants work – if global emissions were to stop tomorrow, the fact that there would be no meaningful reduction in global CO2 concentrations is simply the nature of how stock pollutants work, but there would be very large impacts on future temperatures since the stock would cease to increase. Conflating isn’t the right word. We are pointing out the stock-flow issue. • The stock nature of CO2 emissions is a real challenge for justifying CO2 emissions reductions, but it is centered on justifying the costs of abatement being born by people today in order to create a stream of benefits that grow over time and primarily accrue to future generations. This leads to questions important questions about how decision-makers should think about inter-generational discounting, and what costs should or should not be borne today for the benefit of future generations that will potentially be substantially better off. Dealt with in the IAMs section • It’s worth noting that since CH4 emissions are relatively short lived, they behave much more like a flow pollutant than a stock pollutant. If CH4 emissions went to zero, concentrations would fall relatively quickly, and the temperature effects would happen on a much shorter timescale, but if CH4 emissions fully resumed, concentrations would return to previous levels there would be no lasting impact of the previous reductions. This is to point out that the stock vs. flow distinction also happens between different greenhouse gasses and is not purely a distinction between GHG emission and criteria pollutants. The CH4 case is interesting and we haven’t looked at it. Also natural sources and sinks are complicated for CH4
12	129	Chapter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is PART 2] • Globally mixed. • The challenge here is that abatement costs borne by people in one location benefit people in other locations – spatial externalities. • The next issue is that GHG emissions are globally mixed, so that emissions in any one location have impacts all over the world. This is a distinct issue from the stock vs. flow issue, as the CH4 example above showed a flow pollutant can also be globally mixed. One can also consider a stock pollutant that is not globally mixed, such as groundwater pollution that depends on the stock of contaminants accumulating in the groundwater not just the flow in any one time period as one would see in surface water pollution. • The globally mixed nature of GHG emissions is a real problem for justifying climate policy as the benefits of any one country’s actions primarily accrue to people in other countries. Conversely, a country benefits from the actions of every other country, not just their own actions. This is a problem of game theory and collective action, as unilateral action may not be justified even if collective action would be. It’s worth noting that this isn’t just a problem of scale – these same problems arise for globally

			mixed CH4 emissions even though as noted above they behave more as a flow pollutant, and would arise for any globally mixed pollutant regardless of the scale of the problem. There is an extensive literature on transboundary pollution that explores these issues. Agree with all this, but discussing these points wouldn't change our overall conclusions
12	129	Chapter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is PART 3] Scale. • The challenge here is that solving the problem requires enormous change and potentially enormous costs. However, individual actions need to be considered at the margin. • As discussed in this section and the comments above, stabilizing CO2 concentrations and stopping the increase in global mean temperature requires balancing anthropogenic emissions and removals by sinks. The level global mean temperature stabilizes at would generally depend on the cumulative CO2 emissions up to the point CO2 emissions on net go to zero (the stock of CO2 emissions), and the level of short-lived non-CO2 emissions at that time (the flow of non-CO2 emissions). This would involve an enormous change to the global energy system. The costs of this change would be highly dependent on the timing of reaching net-zero CO2 emissions – in 10 years by 2035 would involve crippling costs to the global economy, in 100 years by 2125 would involve a far more gradual transition and likely impose minimal costs when discounted back to today. • What is missing in this chapter is an acknowledgement that policy needs to be thought of at the margin. Do the marginal benefits of the policy equal or exceed the marginal costs? This is how economists think of these problems and the essence of how the government conducts cost-benefit analysis to inform decision-makers under E.O. 12866. The case study presented in section 12.2 poses the wrong two question. Showing that a policy's emissions reductions are small relative to global emissions, and the resulting impact on global temperatures is also small is tautological. No individual policy will solve climate change, but that does not mean that the individual policy is not justified. The relevant questions for decision makers are: (1) what is the cost of the marginal ton of emissions reductions by this policy? and (2) are those marginal costs smaller than the marginal benefit of a ton of emissions reductions? In practice, question (2) is very difficult to answer, and requires judgements about how to value benefits to Americans vs. benefits to the rest of the world, how to discount benefits that accrue to future generations, and how to consider the impacts U.S. actions have on the likelihood that other countries will take actions that benefit the U.S. These are difficult questions that need to be answered to justify climate policy, and this section would be improved by acknowledging that these are the questions that need to be addressed instead of the awkward argument that the problem is big, and individual policies are small therefore they can't be justified. Ch 12 is only focused on the scale problem. The reviewer is correct that even if the effects are small that doesn't mean they shouldn't be undertaken. Ch 11 is where the logic of cost-benefit analysis including marginal considerations is explored.

12	129	Chap ter	• [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is the full comment] • Section 12.1 is titled, “The scale of the problem,” is framed around contrasting criteria air contaminants with CO2 emissions; however, there really are three separate issues that need to be disentangled: § Stock vs. Flow. • The challenge here is that abatement costs borne by people today benefit people in the future – temporal externalities. • CO2 emissions are a stock pollutant, so impacts depend on the cumulative emissions to date, whereas traditional criteria are a flow pollutant and impacts depend on the emissions at that point in time. Emissions of a stock pollutant going to zero will not affect impacts at that point in time, as the stock remains unchanged, but will have large impacts in the future as the stock will cease to increase until emissions resume; whereas emissions of a flow pollutant going to zero will immediately eliminate impacts, but impacts will have no lasting effects on future impacts as they will immediately resume when emissions resume. • The sentence at the end of the second paragraph of this section reads, “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate.” This is conflating the expectations of how stock and flow pollutants work – if global emissions were to stop tomorrow, the fact that there would be no meaningful reduction in global CO2 concentrations is simply the nature of how stock pollutants work, but there would be very large impacts on future temperatures since the stock would cease to increase. • The stock nature of CO2 emissions is a real challenge for justifying CO2 emissions reductions, but it is centered on justifying the costs of abatement being born by people today in order to create a stream of benefits that grow over time and primarily accrue to future generations. This leads to questions important questions about how decision-makers should think about inter-generational discounting, and what costs should or should not be borne today for the benefit of future generations that will potentially be substantially better off. • It’s worth noting that since CH4 emissions are relatively short lived, they behave much more like a flow pollutant than a stock pollutant. If CH4 emissions went to zero, concentrations would fall relatively quickly, and the temperature effects would happen on a much shorter timescale, but if CH4 emissions fully resumed, concentrations would return to previous levels there would be no lasting impact of the previous reductions. This is to point out that the stock vs. flow distinction also happens between different greenhouse gasses and is not purely a distinction between GHG emission and criteria pollutants. § Globally mixed. • The challenge here is that abatement costs borne by people in one location benefit people in other locations – spatial externalities. • The next issue is that GHG emissions are globally mixed, so that emissions in any one location have impacts all over the world. This is a distinct issue from the stock vs. flow issue, as the CH4 example above showed a flow pollutant can also be globally mixed. One can also consider a stock pollutant that is not globally mixed, such as groundwater pollution that depends on the stock of contaminants accumulating in the groundwater not just the flow in any one time period as one would see in surface water pollution. • The globally mixed nature of GHG emissions is a real problem for justifying climate policy as the benefits of any one country’s actions primarily accrue to people in other countries. Conversely, a country benefits from the actions of every other country, not just their own actions. This is a problem of game theory and collective action, as unilateral action may not be justified even if collective action would be. It’s worth noting that this isn’t just a problem of scale – these same problems arise for globally mixed CH4 emissions even though as noted above they behave more as a flow pollutant, and would arise for any globally mixed pollutant regardless of the scale of the problem. There is an extensive literature on transboundary pollution that explores these issues. § Scale. • The challenge here is that solving the problem requires enormous change and potentially enormous costs. However, individual actions need to be considered at the margin. • As discussed in this section and the comments above, stabilizing CO2 concentrations and stopping the increase in global mean temperature requires balancing
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		anthropogenic emissions and removals by sinks. The level global mean temperature stabilizes at would generally depend on the cumulative CO2 emissions up to the point CO2 emissions on net go to zero (the stock of CO2 emissions), and the level of short-lived non-CO2 emissions at that time (the flow of non-CO2 emissions). This would involve an enormous change to the global energy system. The costs of this change would be highly dependent on the timing of reaching net-zero CO2 emissions – in 10 years by 2035 would involve crippling costs to the global economy, in 100 years by 2125 would involve a far more gradual transition and likely impose minimal costs when discounted back to today. • What is missing in this chapter is an acknowledgement that policy needs to be thought of at the margin. Do the marginal benefits of the policy equal or exceed the marginal costs? This is how economists think of these problems and the essence of how the government conducts cost-benefit analysis to inform decision-makers under E.O. 12866. The case study presented in section 12.2 poses the wrong two question. Showing that a policy’s emissions reductions are small relative to global emissions, and <i>the resulting impact on global temperatures is also small is tautological. No individual policy will solve climate change, but that does not mean that the individual policy is not justified.</i> The relevant questions for decision makers are: (1) what is the cost of the marginal ton of emissions reductions by this policy? and (2) are those marginal costs smaller than the marginal benefit of a ton of emissions reductions? In practice, question (2) is very difficult to answer, and requires judgements about how to value benefits to Americans vs. benefits to the rest of the world, how to discount benefits that accrue to future generations, and how to consider the impacts U.S. actions have on the likelihood that other countries will take actions that benefit the U.S. These are difficult questions that need to be answered to justify climate policy, and this section would be improved by acknowledging that these are the questions that need to be addressed instead of the awkward argument that the problem is big, and individual policies are small therefore they can’t be justified.
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Ch	page	Para	Comment or Suggested Edit
2	5	Fig 2.2	The graph is not relevant to the discussion. It should only, at most, cover the time period since the last glacial maximum, which occurred ~20 kyr BCE, and common practice is to concentrate on the last 1000 years. Figure 2.2 has been deleted
3	11,12	Sec 3.1.1	There is no quantification of the effects of TSI and volcanic aerosols that would lead to modifications of the radiative forcing shown in the figures In ch 6 we discuss ranges of TSI forcing that even the IPCC acknowledges.
3	21,22	Sec 3.3	Many of the arguments and references are dated. Further, the challenge posed is to prove a negative, i.e. that the record used by AR6 is not biased by urban heat island effects. On the contrary, while verbally stating uncertainty, the authors cannot make a claim that the AR6 statement is false. Even if one were to accept the Soon, et al value of 0.89 deg C/century, the focus on the land surface warming completely neglects the contribution of the oceans to global surface temperature change, which must be considered in any discussion of surface temperature change. The underlying studies frame statistical tests appropriately to test for the presence or absence of an effect. Yes ,the literature is dated and the topic needs renewed attention. The question is bias in the land record, but no one is arguing all surface warming is due to urbanization.
4	30	Sec 4.4	The statement "TCR is more generally related to peak warming and better constrained by historical warming, than ECS." requires further context. While true that the "peak warming" rate achieves a maximum around 70 years, temperature increases continue for several centuries and approaches the ECS value asymptotically. Further, the Lewis (2023) arguments were placed in context by Sherwood and Forest (2024), that identified multiple recent ECS studies that showed, collectively, that the PDF in their original Sherwood, et al paper could not be narrowed. Additionally, the reference to Sherwood et al (2020) is incorrect. It omits many authors and the authors that are listed are not in the correct order. Reference to peak warming deleted.
5	37, 38	Sec 5.4	The analysis presented of the IPCC AR5 figure, Fig 5.6 in the current document, is outdated and should be removed. The issue IS addressed in the AR6, but not graphically, in the text reproduced by the authors. If the section is retained, it should be moved ahead of Section 5.3 to present the material in the correct order chronologically. The analysis in Fig. 5.6 matches the updated data in Fig 5.7, and it is relevant to show that the information was included in the AR5 but only in a figure in the Supplement. The order of presentation in the chapter is appropriate.
6	57	para 1	The conclusion "The rise in Tmin has been strongly related to the growing presence of manufactured surfaces around the weather stations over the last 100+ years (the so-called urban heat island effect; Section 3.3 and Spencer et al. 2025)." is only found in an author's self-citation of Spencer, et al, (2025) that does not appear in the references at the end of Chapter 6. Further, the trend of greater increases in Tmin relative to Tmax is documented and explained in Easterling, et al (1997). https://doi.org/10.1126/science.277.5324.364 ; Thorne, et al (2016) https://doi.org/10.1002/2015JD024584 . The trend cannot be attributed to UHI effects. We added citations to the literature to substantiate the point.
8	85	para 5	"... datasets with high TSI variability can explain more than 70 percent of the temperature variability since preindustrial times." Variability on what time scales? 11-year cycles? How would this impact the well documented surface temperature increase of > 1 deg C global temperature change since 1900?

			There is a whole spectrum of variability in TSI beyond the 11-year cycle. These are discussed in the papers we reference.
8	85,86,87	"Natural variability of large-scale ocean circulations"	The discussion neglects the influence of vertical mixing on surface temperature. The global ocean has warmed, as documented by increases in global ocean heat content, e.g. Murphy, et al (2009) doi:10.1029/2009JD012105 We do not understand the comment.
8	88,89	Optimal fingerprinting discussion	This section is hardly a balanced and objective review. The report authors are known opponents of optimal fingerprint approaches and have been a loud, but very small minority voice. It is interesting that even they conclude "...these analyses do not falsify results of the IPCC optimal fingerprinting method..." The point is that falsification would require redoing all the underlying studies. The findings however show that the method is flawed and the justification for relying on it is invalid.
8	90,91,92	Section 8.4	This discussion is incomplete and fails to take into account the extensive literature on cloud and surface albedo feedbacks.. There is an extensive discussion about the post 2015 period and recent record annual global surface temperatures, implying, but not stating, that recent changes are the result of natural variability, or decreases in atmospheric aerosol concentrations. Comparing the radiative forcing from these changes with long-term GHG forcing, particularly CO2 is misleading to the average reader. If the reduction in albedo can be tied to atmospheric cloud and aerosol changes, as the authors state, they cannot ignore the likelihood that the changes are the result of anthropogenic factors, i.e. sulfate aerosol reduction through cleaner technology and the well-documented positive low-cloud feedback. The discussion is incomplete because the underlying science is incomplete, as we emphasize. We are surveying a complex area of ongoing research without taking a strong position ourselves.

Full document			In the limited time allowed, this reviewer concentrated on sections related to the physical climate and climate change. Frankly, the document was discouraging. Secretary Wright wants a " ... a more thoughtful and science-based conversation about climate change and energy." I find that this report distorts the science in much the same way as the media coverage about which he complains. Most notable are the omissions or under-reported significant climate changes, such as sea-ice decline, changes in the global water cycle and increases in heat-stress due to increases in absolute humidity (from water-vapor feedback). Further, the examples used by the report authors are narrow and appear to be selected to emphasize uncertainty, while the more rigorously evaluated science that contradicts their limited discussion is ignored, perhaps because it does not fit their narrative. This is unfortunate, because I believe it detracts from the much needed discussion about the future, including energy policies, technologies and trade-offs. I encourage DOE to start the discussion by accepting the well-reviewed and broadly accepted scientific conclusions of the IPCC Working Group 1, with respect to the observations and analyses of climate change in the 20th and 21st centuries. Skepticism regarding predictions/projections of future climate based on posited scenarios is justified. As a member of the physical climate research community, I believe there are better uses for the models (and the computer resources they consume) than scenario projection simulations, to inform the discussion that is urgently needed about the future. Comments noted.
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Chapter Number	pg	para	Comment or Suggested Edit
Foreword	vii	4	The stated charge to the team was to summarize the current state of climate science, but in the Preface the team states that it chose to focus on topics that are downplayed in or absent from current assessment reports. To accurately describe the contents of the report, the Foreword should also state that the report is a summary of the things that the author team thinks have been downplayed in major climate assessment reports. Noted, the Preface has been modified. Our charge was not to summarize the whole of climate science.
Foreword	vii	8	The statement about climate change not being the greatest threat facing humanity is a value judgement. Since the Secretary criticizes others for blurring the line between scientific conclusions and policy recommendations in the second, fourth, and sixth paragraphs of this Foreword, it is hypocritical to offer a value judgement without clearly labeling it as such and noting that such conclusions must necessarily involve one's beliefs in addition to scientific information. We did not write the Secretary's foreword.
Exec Summ	viii	2	It is misleading (cherry picking) to only mention "global greening" (i.e., the influence of elevated CO2 on plant growth) here without also noting the impacts of elevated temperatures and changing precipitation patterns on ecosystem health and agricultural productivity. (This comment is also true of the underlying content on pages 3-7) This issue has been addressed with wording changes to acknowledge the other contributors.
Exec Summ	viii	2	It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems and fisheries. (This comment is also true of the underlying content on pages 8-9) The statement has been removed.
Exec Summ	viii	3	It is inaccurate to say that "scenarios of CO2 emissions have tended to overestimate observed levels". As the authors themselves note on page 15, it is impossible to reliably predict societal behavior regarding energy production and other sources of emissions, so the climate science community has never provided or suggested that there is a single predictive scenario against which future emissions could be judged. Rather, there has always been a range of projected emissions scenarios, and emissions have always tracked within the envelope of those scenarios. The authors make a reasonable point in the full text about the large number of climate studies that have used RCP 8.5, whereas actual emissions have recently been closer to RCP 4.5. This would be a more appropriate finding to include here in the executive summary. The point being made here is that observations have tracked the low end of the envelopes, a problem going back decades. See Figure 3.2.1
Exec Summ	viii	4	Stating that climate models "offer little guidance on how the climate responds to elevated CO2" is at best an unjustified (and at worst a biased) judgement given that the authors chose to focus only on the shortcoming and deficiencies of these models, and do not account for the progress made in improving the ability of these models to reproduce many key aspects of observed climate change. The same is true for all of Chapter 5. It is informative for readers to see key ways in which models fail to match observations especially those most relevant for policy making. The continuing wideness of the range of responses is an important limitation to their fitness for purpose.

Exec Summ	viii	5	Stating that climate models "generally run hot" is an inaccurate and misleading summary statement. A large number of papers and scientific assessments have validated the ability of climate models to accurately simulate many major aspects of global climate. Like all models, climate models are imperfect, and some models have recently shown a tendency to produce higher climate sensitivities--the IPCC AR6 acknowledged this "hot model problem" and there has been considerable discussion in the scientific literature about it and its implications for impacts studies. But this is a relatively recent phenomenon, and there could be other reasons for the recent mismatch (i.e., under-estimates of the reduction in aerosol cooling due to air pollution controls). A balanced scientific assessment would also note, for example, that climate model projections from the 1970s and 80s have accurately predicting the observed trend in global temperature over the past few decades. Our statements are substantiated by the Figures in Ch 5 (especially Figs 5.2 - 5.4). As we discuss, the problem of the tropospheric mismatch goes back decades.
Exec Summ	viii	6	It is misleading and inaccurate to say that most extreme weather events do not show long terms trends. It is true that some kinds of extreme events, like tornadoes, have not shown appreciable or detectable changes, and that changes in wildfire must account for changes in land management. But a "summary of the current state ofthe science" should acknowledge that there is clear evidence that heat waves are becoming more frequent and more extreme, extreme precipitation and nuisance flooding are becoming more common, etc. (This comment is also true of the underlying content in Part II) The chapter presents a great deal of data that substantiates our summary statement. We also provide clear indications on heatwave trends including where they are increasing in frequency. Our assessments match those in the IPCC and NCA documents.
Exec Summ	viii	6	It is misleading to state that the aggregate sea-level rise trend in U.S. tide gauges is not accelerating, because as noted in the same sentence, there are significant regional differences in SLR (primarily due to differences in land subsidence), so only looking at domestic gague data is insufficient to determine if sea-level rise--an inherently global process--is accelerating, with regional factors superimposed on that global trend. There is clear evidence that global sea level rise is accelerating. Moreover, while land subsidence has offset sea level rise in some U.S. regions, the opposite is true in others, and in those reasons the combined effects of sea level rise and subsidence are posing considerable risks to people and infrastructure in those regions...but this important context is omitted. (The same is true of the sea level rise analysis on pages 75-78.) We state that global sea level rise has accelerated in recent decades. The reviewer needs to provide evidence for the claim of acceleration. SLR is a regionally-heterogeneous phenomenon and we discuss the differences by location. We present tide-gauge data for many locations so readers can see the situation for themselves.
Exec Summ	viii	9	Most of the sentences in this paragraph are not factual in nature. For example, the call for uninterrupted observations of the global climate system is a research recommendaiton that is outside the remit of this report and is not supported by text within the document. The same sentence also implies that current emissions scenarios are not "realistic", which is not a defensible statement given that historical emissions have tracked within the envelope of previous emission projections (see comment above and Figure 3.2.2), and argues that climate models should address biases and uncertainties, which is something that every climate modeling team already spends an enourmous amount of time doing. If retained, the non-scientific portions of this paragraph should be moved to the Preface, and the misleading statements should be corrected. The paragraph has been moved to the end of Chapter 12. See above regarding emission scenarios.

Preface	ix	1	The focus on "whether carbon dioxide emissions endanger the U.S. public" is slightly different from the stated focus in the Foreward on "the Nation's climate". This distinction is important because climate change and its impacts outside of U.S. borders can endanger the U.S. public both directly (e.g., global processes affecting sea level rise in the United States, or the impacts of climate change on overseas military installations) and indirectly (i.e., impacts of climate change on international agricultural production and trade dynamics). The reference to endangerment has been removed.
2	3	1	The two summary statements provide an extremely narrow and misleading view of "direct impacts of CO2 on the environment" (the chapter title). The most obvious direct impact of CO2, in the context of climate change, is its role in global radiative forcing, which is covered in the next chapter but not mentioned here. The chapter should at a minimum be retitled, but better yet combined with the following chapter which discusses other aspects of increasing CO2. The effect of CO2 on the climate takes up the bulk of the report.
2	3	2	It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems, fisheries, and other processes. The evidence we cite shows that pH levels are in the range of natural variability. Whether the rate of change is, is much more difficult to establish because of the limitations of paleo records. Also the spatial heterogeneity is not subject to comprehensive measurement, which precludes straightforward assessment.
2	5	1	It is misleading to show (only) a graph of CO2 levels over hundreds of millions of years. These timescales are generally not relevant to processes and issues surrounding anthropogenic CO2 increases. For example the authors in multiple places make statements about CO2 levels during the last glacial maximum, but those fluctuations are undetectable on a graph with such a long timescale. The figure has been removed.
2	8	1	Acidification is not a misnomer...the word literally means to make something more acidic, which is what is happening. The authors may choose to argue that the term is misleading since the oceans are slightly basic, but that is not the same thing as a misnomer. We consider it a misnomer for the reasons stated. The oceans are not becoming acidic.
2	8	1	It is misleading and largely irrelevant to discuss ocean pH levels tens of thousands or millions of years ago, because that timescale is not relevant to the impacts associated with anthropogenic ocean acidification on ocean life. It is well documented that recent changes in ocean pH are happening ~100 times faster than natural fluctuations prior to human CO2 emissions, and marine species must adapt to changes in conditions on timescales of a few of their lifetimes, which is clearly not millions of years. The referee needs to provide specific sources for these statements. Also, it is a relevant point to make if current marine life evolved under conditions of much lower pH.
2	9	4	Similar to previous comment--changes in marine life over hundreds of millions of year has little relevance to the survival of marine species on decadal timescales due to anthropogenic ocean acidification. Are the authors trying to suggest that U.S. society would be well served by going back to conditions during the Jurassic? See earlier response.

3	13	2	The IPCC probably discounted the results reported in Connolly (2021) because that study included methodological errors that were documented in several subsequently publications, which the authors do not acknowledge. A serious assessment of TSI would not cherry-pick a single study, especially one that has been shown to include serious errors. The reviewer is probably referring to a comment by Richardson and Benestad, but Connolly et al. replied effectively to their critique.
3	14	4	It is unclear what the authors mean by "other natural sources of energy imbalance". If the authors are aware of a plausible additional source of energy imbalance they should state what it is rather than making vague statements without providing any evidence that such sources might exist. Surely the reviewer acknowledges that there are unknowns in the climate system
3	14	5	This is one of several places where the authors discuss the CO2 levels at which C3 plants begin dying in the context of the last glacial maximum. This is misleading, because there is no evidence that CO2 levels would have continued falling below the levels of the last glacial maximum, and irrelevant to the stated focus of this report, because they rebounded to 280 ppm many centuries before human activities began producing large amounts of CO2. The reviewer needs to provide evidence for the assertion that CO2 levels would not have continued falling.
3	15	1	The oceans and land surface absorb more like 60% of CO2 emissions. The 50% figure is repeated multiple times in the ensuing pages and should be corrected. We are unfamiliar with the 60% number; the sources with which we are familiar generally report numbers closer to 50%. The reviewer has not cited any sources for his or her statement.
3	20	2	The final sentence on this page is misleading and confusing as written. Most studies of the land carbon sink suggest that the rate at which it is increasing is declining, and several studies suggest that the ocean sink is declining. The authors should also explain the relevance of their statements here, because it isn't clear. Our statement is consistent with the sources we cite. Unfortunately the reviewer did not provide references.
4	26	6	The inclusion of a paragraph with high-level summary statements about climate policy here is confusing and inappropriate. This content belongs in chapter 11. We only make a brief introductory statement and otherwise defer the discussion to Ch 11.
4	29	1	The point about observed global temperature trends being consistent with both high-ECS high-aerosol and low-ECS low-aerosol worlds is an important one. It would be good to acknowledge that uncertainty in ECS is not just due to uncertainties in climate models, but also the lack of accurate measurements of pre-industrial aerosols and thus anthropogenic changes in aerosol forcing. And this uncertainty cuts both ways--if we live in a high-ECS world that has been "masked" by strong aerosol cooling, reducing air pollution could result in rapid warming (and this may be linked to the "hot model" problem as well). Agreed
4	29	2	The point about ECS values derived from past climate states (especially cooler ones) possibly not being totally representative of the current climate is another good point, one that would be good to acknowledge in their earlier and later discussions about uncertainty and the rationales for emissions reductions (e.g., on page 26 and in Chapter 11). Agreed.

4	30	1	The relatively shallow treatment on TCR relative to ECR here is puzzling, since the authors acknowledge that it is better constrained, and it is also a more relevant value for projected warming over the next several decades. The first sentence here also describes it as an observational constraint, but it is not, it is a metric that can be produced from either data or models (or both), and climate models are routinely used to run TCR experiments. ECS is more widely-used than TCR which is why we focus more attention on it.
5	32	1	A more accurate title of this chapter would be "deficiencies in climate models" because the authors focus almost exclusively on processes and features that models have struggled to reproduce, rather than a balanced assessment that also indicates what these models do well. We changed the title to take this into account.
5	34	1	Scaffeta (2023) has been widely criticized in the scientific literature for its methods and conclusions. These results should not be presented without acknowledging these concerns, or better yet, the authors should attempt to survey the literature on this topic rather than presenting results from a single controversial paper. The reviewer is referring to an exchange regarding a different paper. We are unaware of any published critiques of the Scafetta paper we cite.
5	34	2	Spencer (2024) is not a peer reviewed journal paper and is not really appropriate to include here when there are many papers on this topic that have been peer reviewed. The reviewer should have provided references. We are unaware of any peer reviewed papers that present the comparison we show. We provide traceable accounts for the underlying data, all of which is from official sources.
5	35	1	The statement that the signal for anthropogenic greenhouse warming emerges first and most strongly is not supported and is inconsistent with my understanding of climate dynamics. The following sentence is also dubious (and probably backwards) since models run with observed surface temperatures tend to produce much better mid-tropospheric temperature simulations. The statement about early and strong emergence of the CO2 signal in the tropical troposphere is in the IPCC TAR and subsequent reports. Even models constrained with observed sea surface temperatures produce excess amplification aloft.
5	36	1	In most places the authors correctly describe the discrepancy between models and observations as a mismatch, which is appropriate because observations of mid-tropospheric temperatures are also subject to uncertainty (as indicated in the error bars in Figure 5.4). This is one of the reasons for the IPCC confidence assessment noted in the following paragraphs. However, here and in a few other places in this section the writing implies that differences can be solely attributed to model deficiencies. We don't take a position on the ultimate cause however we do note that the biases are pervasive across models and multiple observational data sets.
5	37	1	This section should be combined with the previous one as it is really just elaborating on the same discrepancy between climate models and observational estimates of tropospheric temperatures. One section discusses the discrepancy of trends and the other discusses the discrepancy of amplification rates, which is why the sections are separate.

5	39	1	There has indeed been considerable controversy about this particular metric. It is curious that the authors choose to cite two older papers here (2008 and 2009) rather than the rich recent literature, especially since they went to the trouble of updating on of their graphics with 2024 data. Recommend including a more balanced assessment of this discrepancy, it's potential causes, and recent efforts to address it, as well as noting that climate models are able to accurately capture many other aspects of climate change. Again, it is unfortunate that the reviewer did not provide any citations to this rich recent literature. We cited the key papers we are aware of.
5	39	1	This entire section is very misleading as it cherry-picks a specific result and takes it out of important context. The reason why stratospheric cooling has slowed (and, at least in one study, even warmed) in the past two decades is due to the recovery of the ozone layer. This is clearly stated in the Philipona et al article cited by the authors and in the IPCC report. Additionally, satellite-based estimates of stratospheric temperature (which is data the authors highlight in the previous section) do not show the same trends. This section should be removed or amended to note that stratospheric temperatures are influenced by multiple factors and that a comprehensive analysis of stratospheric temprature trends is fully consistent with those projected under climate warming scenarios. We have added a sentence discussing the ozone recovery issue and make reference to the recent Santer et al. study.
5	41	1	Many observational studies have shown that snow cover is decreasing, and have explained why it is more meaningful and useful to look at spring trends in snow cover, as well as why observations of snow cover can be uncertain. The issue here is model projections versus observations. Again, the reviewer provides no citations.
5	42	4	The authors provide a relatively accurate survey of results regarding hurricane numbers and landfall frequency, which have indeed not shown any trends. But their analysis of hurricane intensity, which has been shown in many studies to increase, is lacking...the chart showing just estimated windspeeds of the top ten landfalling storms is really weak given the analytical talents of the author team. They also do not provide any discussion of the physical basis for why hurricane numbers may not be changing while the intensity of the strongest hurricanes is expected to increase, nor analyze any data in the context of those conclusions. The challenge for global intensity metrics is that the satellite record prior to 1980-1990 (experts disagree on the data quality during this period) is inadequate, which is why we focus on the Atlantic hurricane data. Also there is no theory for hurricane number; that is a topic associated with substantial uncertainty.
6	47	5	Long term persistence is not a recognized property or phenomenon associated with rainfall data. The use of such a statistical technique, especially one that is not widely recognized or used in the hydroclimate community, demands additional justification. We have rewritten the text to remove specific reference to LTP.

6	53	4	The authors have cherry picked results throughout this section. For example, they have selected only a few quotes from IPCC and NCA describing extreme heat. The absolute single daily maximum temperature for a given year, for example, is a poor statistic for assessing statistical changes in extreme heat (it would be like comparing the tallest person in each country to try to calculate change in average height). A complete and comprehensive review of the underlying assessments and the data it cites clearly shows that extreme heat has been increasing in North America. The reviewer fails to identify any data or conclusion from the IPCC or NCA that differs from our assessment, and fails to cite any sources to justify this comment.
6	56	1	The "climate less prone to extremes" is a misleading statement. If minimum temperatures are increasing faster than maximum temperatures (which is an expectation of climate change based on basic physical principals), then the difference between warm and cold extremes on many timescales is expected to decrease. There are reasonable points to be made regarding observational deficiencies, regional variations in extreme events, and the potential benefits of reductions in extreme cold, rather than coming up with misleading statistics. But we show that extreme heat has also declined since the 1930s – Figures 6.3.1 and 6.3.3 refute the reviewer's statement.
6	58	3	The NCA5 heading is not a controversial statement, it simply says that things are changing, which they are by the author's own admissions and graphs. It does not suggest pervasive positive trends, as the authors suggest it does. We're not sure what sentence the reviewer is referring to.
6	61	3	The statistical techniques used in the 2019 paper are highly non-standard for evaluating precipitation statistics, and the 2024 results have not been peer reviewed. The results reported in the NCA and IPCC and the underlying studies have clearly demonstrated that extreme precipitation is increasing. The 2019 paper uses ordinary least squares to compute the trend, and a standard variance estimator from the econometrics literature to assess significance. As we point out, we also find evidence of increasing precipitation averages and extremes but only when selecting certain start dates.
6	61	7	The relevance of the paragraph on 19th century and paleoclimatic rainfall events is unclear. If anything, the fact that such extremes have occurred in the past argues for more aggressive adaptation measures to ensure that damages won't be as high if they happen again (even notwithstanding potential changes in risk due to climate change). Note, however, that additional context is provided in the box that follows two pages later. We agree that discovery of extreme events in the 19th century records indicates that disaster planning may need to encompass a wider range of risks.
6	62	1	The choice of looking at (only) 5-day precipitation totals is questionable. Most rainfall events, including the most extreme and damaging precipitation events, are typically on a daily timescale. Again, the reviewer provides no citations or evidence. Our results are robust to different day intervals, and we refer to 1- and 2-day results as well.
6	68	3	Perhaps this is more germane to the sea level rise section, but nuisance (high tide) flooding due to sea level rise has been observed across much of the United States. This is a topic we did not address.

From: John Christy <climateman60@gmail.com>
Sent: Thursday, July 31, 2025 1:45 PM
To: Ross McKittrick; Judith Curry; Roy Spencer; Steve Koonin; Cohen, Seth; Joshua Loucks; Travis Fisher
Subject: Link counts

All

My IT guy ran a quick look at the number of times the data/information files we put up here at UAH were accessed since Tuesday. It looks like between 200 and 300 so far. He'll work up a clean list of each file and how many times each was downloaded.

It would be nice to have a DoE site to put these in for public access, but at least we know the idea of transparency is working as people are jumping on the datafiles and not having trouble downloading them.

John C.

From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 8/1/2025 2:14:02 AM
To: Judith Curry [curry.judith@gmail.com]
Subject: Re: [EXTERNAL] DOE reviews
Attachments: image001.png; image002.jpg

Is there a non paywall version of the Kim Strassel article?

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Many thanks in advance.

Best wishes, Leo

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Leo Hickman

Editor, Carbon Brief

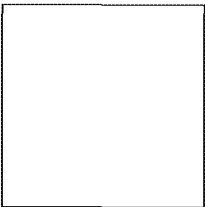
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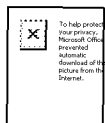
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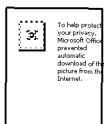
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Subject: [EXTERNAL] DOE reviews

Ross, if you can send me the latest version of the 8 DOE review responses, i can clean those up, verify changes were made, and send around for approval. Would be good to get those out of the way before the public comments

On Thu, Jul 31, 2025 at 12:27 PM Roy Spencer <roywspencer@hotmail.com> wrote:

| Ironict hat no one cared when MY work was mischaracterized by the 97-Percenters' as being part of the 3%, even though by their criteria I was part of the 97% consensus.

I complained, but all they said was, "well, we put you in the 3 percent category".

The bias is rampant.

-Roy

From: Ross McKittrick <ross.mckittrick@gmail.com>

Sent: Thursday, July 31, 2025 11:27 AM

To: Roy W. Spencer <roywspencer@hotmail.com>; Judith Curry <curry.judith@gmail.com>; John Christy <climateman60@gmail.com>; Steven Koonin <steven.koonin@googlemail.com>; Josh Loucks <loucksj14@gmail.com>; Cohen, Seth <seth.cohen@hq.doe.gov>; Fisher, Travis <travis.fisher@hq.doe.gov>

Subject: Fwd: Fw: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

John and I got this from Tim Vogelsang at MSU. Carbon Brief is contacting everyone whose work was cited trying to gather up claims of misrepresentation. As Tim notes, there is no option on the form for saying your work was correctly characterized.

From: Vogelsang, Timothy <tjv@msu.edu>

Sent: Thursday, July 31, 2025 12:19 PM

To: Ross McKittrick <rmckitri@uoguelph.ca>; John Christy <climateman60@gmail.com>

Subject: RE: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

CAUTION: This email originated from outside of the University of Guelph. Do not click links or open attachments unless you recognize the sender and know the content is safe. If in doubt, forward suspicious emails to IThelp@uoguelph.ca.

If you look at the pdf I was sent with the instructions, there is no option to report that someone's research has been correctly characterized. That's not a very scientific factchecking exercise, is it!

Tim

From: Ross McKittrick <rmckitri@uoguelph.ca>

Sent: Thursday, July 31, 2025 12:15 PM

To: Vogelsang, Timothy <tjv@msu.edu>; John Christy <climateman60@gmail.com>

Subject: Re: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

I've heard of Carbon Brief but only read snippets of their articles cited elsewhere. They seem to be heavily into promoting renewables.

It's interesting to watch the machine swing into gear. There is a public comment docket opening up and I expect there will be quite the avalanche of material submitted, which we will need to prepare responses to, all of which will form part of the public record. If the comments are substantive we'll readily make revisions. We responded to a lot of

comments from the internal DoE staff during the pre-publication review stage. But some of the most hostile comments didn't provide any data or citations in support so we couldn't do anything with them.

Ross

Dr. Ross McKittrick

Professor of Economics

Department of Economics and Finance

rossmckittrick.com



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From: Vogelsang, Timothy <tjv@msu.edu>

Sent: Thursday, July 31, 2025 12:02 PM

To: Ross McKittrick <rmckitri@uoguelph.ca>; John Christy <climateman60@gmail.com>

Subject: FW: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

CAUTION: This email originated from outside of the University of Guelph. Do not click links or open attachments unless you recognize the sender and know the content is safe. If in doubt, forward suspicious emails to IThelp@uoguelph.ca.

Ross and John,

I just got this email. Maybe you know about this group. I'm sure this is just the tip of the iceberg of pushback coming.

Tim

From: Leo Hickman <leo.hickman@carbonbrief.org>

Sent: Thursday, July 31, 2025 11:49 AM

To: Leo Hickman <leo.hickman@carbonbrief.org>

Subject: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

Hello,

I'm contacting you because we have noticed that at least one of your studies has been cited in a new report published this week by the US Dept of Energy titled, "A Critical Review of Impacts of Greenhouse Gas Emissions on the U.S. Climate."

A number of scientists cited in the report have already publicly highlighted that their findings have been falsely or misleadingly characterised. It seems that the report is intended to be used as scientific justification by the Trump administration in its efforts to revoke the US Environmental Protection Agency's "endangerment finding" on greenhouse gases.

Carbon Brief is now seeking your help to assess whether your own study, or indeed your area(s) of expertise more widely, have been mischaracterised in the report. This is part of a wider 'crowdsourced' fact-checking effort we are now convening to draw on inputs from experts in their respective fields.

I have attached a PDF with some instructions on how you can participate with your own insights and reflections, should you wish. (The instructions include ways to do this anonymously and securely, if that is your preference.)

Additionally, if you know of a colleague or co-author who might wish to participate, please feel free to forward this email to them.

Our deadline for submissions is Monday 11 August 2025 - 0900 GMT.

Many thanks in advance.

Best wishes, Leo

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Leo Hickman

Editor, Carbon Brief

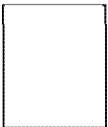
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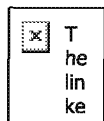
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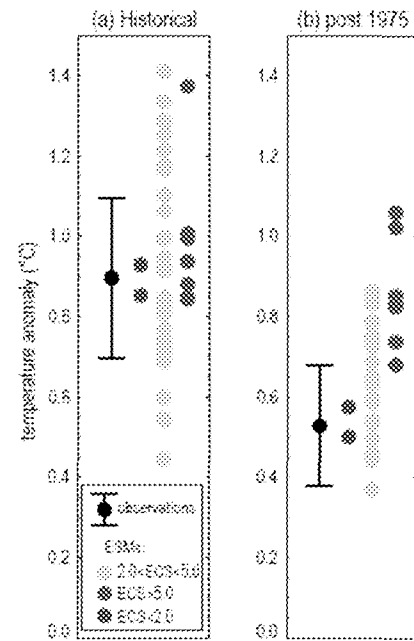
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Pg	Par a	Comment or Suggested Edit	
viii	2	The greening effect can't be due to increase in CO2 alone. The fertilization effect needs Nitrogen and phosphorous. There is observational[1] evidence that nitrogen available to plants is decreasing with increasing CO2 and thus acting to limit fertilization effect. Secondly, the greening of some portions of the planet are likely due to changes in precipitation patterns associated with changing climatic conditions and not entirely attributable to fertilization effect. We will also need to consider that the temperature effect on photosynthesis will also be a limiting mechanism to any continued greening due to fertilization in the future [2]. I recommend acknowledging that the greening is not attributable to CO2 alone and continued greening in the future with increasing CO2 is uncertain. Changed sentence to “Elevated concentrations of CO₂ directly enhance plant growth, globally contributing to “greening” the planet” Agreed I'm a little confused regarding this (and additional comments below) about global greening being due to higher temperatures and not just increasing CO2. So what? If warming is due to more CO2, then it's a win-win for global greening, right?	[1] Rachel E. Mason et al. Evidence, causes, and consequences of declining nitrogen availability in terrestrial ecosystems. Science 376, eabh3767(2022). DOI:10.1126/science.abh3767 [2] C.E. Moore, et al. The effect of increasing temperature on crop photosynthesis: from enzymes to ecosystems. Exp. Bot., 72 (8) (2021), pp. 2822-2844
viii	3	I am glad we acknowledge that CO2 causes warming, though I am not sure why we are not considering other energy sector related emissions that also cause warming (CFCs/HFCs, methane, aerosol effects). It is not clear what is meant by "CO2 emissions have tended to overestimate observed trends". This is not correct, the cumulative emissions track the RCP8.5 scenario the closest [3,4]. While there was a decrease in emissions during the Covid-19 period the emissions are now back on track following RCP8.5. This statement should clarify what is meant by the statement in the text. Sentence deleted. Scenarios of future CO₂ emissions have tended to overestimate observed levels. WE ONLY ASSERT THIS, REFERRING TO RM PAPER. OTHER PAPERS SHOW DIFFERENTLY, AND WE DON'T DISCUSS. ALSO REMOVE THIS SENTENCE FROM CHAPTER, NOT WORTH FIGHTING OVER THIS ONE, OR SPENDING TEXT TO DEFEND THE STATEMENT I AGREE THE PAPERS HE REFERS TO ARE PATHETIC, THO No we mainly cite Hausfather here and are referring to their historical assessment. I don't think we should jettison this whole topic. I suggest deleting reference to McK & Wood and adding discussion of Schwalm-HP exchange. It won't add to the section length. Rewrite sentence in the summary section to read “Climate change simulations require scenarios of distant future emissions. There is evidence that scenarios widely-used in the impacts literature have overstated observed and likely future emission trends.” Then on page 16 add before paragraph beginning “Widespread use of RCP8.5....”: “Schwalm et al. (2020) defended the use of RCP8.5 on the grounds that cumulative CO2 emissions over 2005-2020 track it more closely than the lower RCP scenarios. They also argue that a modified version of the IEA scenarios closely track RCP8.5 in the coming decades. Hausfather and Peters (2020b) responded that the skill of RCP8.5 over those 15 years is due to offsetting errors in its representation of CO2 from fuel use and land use change, and the apparent agreement with IEA in coming decades is due to Schwalm et al. adding in very high land use emissions. The IEA's own projected CO2 emissions track well below RCP8.5.”	[3] C.R. Schwalm, S. Glendon, & P.B. Duffy, RCP8.5 tracks cumulative CO2 emissions, Proc. Natl. Acad. Sci. U.S.A. 117 (33) 19656-19657, https://doi.org/10.1073/pnas.2007117117 (2020). [4] C.R. Schwalm, S. Glendon, & P.B. Duffy, Reply to Hausfather and Peters: RCP8.5 is neither problematic nor misleading, Proc. Natl. Acad. Sci. U.S.A. 117 (45) 27793-27794, https://doi.org/10.1073/pnas.2018008117 (2020).

		These suggested changes do not affect the report pagination. Agree	
viii	4	This paragraph seems to be talking about equilibrium climate sensitivity. The most recent model inter-comparison gives a wider range of climate sensitivities in the range of 1.8 to 5.7 and is wider than estimates of climate sensitivities that have been estimated from paleoclimatic and more recent historical datasets, in the range could be in the range of 2.3 to 4.5 K[5]. The higher sensitivity in the most recent model assessments are an area of active investigation by modelers, the feasibility of a higher range needs to be confirmed with additional observational and process scale modeling [6]. The range for climate sensitivities, 1.8-2.7, should be corrected to the most recent findings, 2.3-4.5. We should also recognize that the (a)earth is a complex system of systems (b)we can't do an experiment to find out what is correct or reduced the uncertainty. As we get better at extracting temperature records and CO2 concentrations from paelo data, there will be better reconstructions and possibly narrower range along with improvements in modeling that resolve many physical, biological and chemical processes as we get to higher and cloud resolving spatial resolutions. Delete this sentence a larger range than data-driven estimates that suggest a response in the range 1.8°C to 2.7°C. SHERWOOD ET AL IS ALSO A DATA DRIVEN ESTIMATE. THE LARGE MODEL RANGE SPEAKS FOR ITSELF We discuss Sherwood et al. in Ch 4. Suggest we change sentence to read “Data-driven methods yield a lower and narrower range.”	[5] Sherwood, S. C., Webb, M. J., Annan, J. D., Armour, K. C., Forster, P. M., Hargreaves, J. C., et al. (2020). An assessment of Earth's climate sensitivity using multiple lines of evidence. <i>Reviews of Geophysics</i>, 58, e2019RG000678. https://doi.org/10.1029/2019RG000678 [6] Zelinka, M. D., Myers, T. A., McCoy, D. T., Po-Chedley, S., Caldwell, P. M., Ceppi, P., et al. (2020). Causes of higher climate sensitivity in CMIP6 models. <i>Geophysical Research Letters</i>, 47, e2019GL085782. https://doi.org/10.1029/2019GL085782
viii	5	This is again not true for the majority of the models in the AR6. Figure 7.19 in the IPCC AR6 report shows that majority of the models exhibit a range within the observational range. The models running hot in the most recent decades are the ones with climate sensitivities grate than 5K, which are 3 out of a total of 40 and it should be noted that about the same number of models also are running cold' compared to observed[7] rewritten para: CURRY The world’s several dozen detailed global climate models offer little guidance on how much the climate responds to elevated CO₂, with the average surface warming under a doubling of the CO₂ concentration ranging from 1.8°C to 5.7°C, a larger range than data-driven estimates that suggest a response in the range 1.8°C to 2.7°C. COMBINE PARA Detailed Global climate models also generally run “hot” in their description of the climate of the past few decades show too much warming at the surface and too much amplification of warming in the lower- and mid-troposphere. They also produce and too much stratospheric cooling and too much snow loss, ONLY REFERS TO US and too much warming in the U.S. Corn Belt. ODD THING TO MENTION WITHOUT CONTEXT The combination of overly sensitive models and implausible extreme scenarios for future emissions has exaggerated projections of future warming. CURRY I don’t think we should give up so much on our text. Hausfather et al. got an apparent match both by using a data interval with strong volcanic and ENSO end-point effects and incorrect time series analysis (unfortunately GRL wouldn’t publish a comment and I never got around to submitting it as a paper but the details are at https://judithcurry.com/2020/01/17/explaining-the-discrepancies-between-hausfather-et-al-2019-and-lewiscurry-2018/). Here is IPCC Fig 7-19 panels a&b as cited by the Reviewer (the others refer to distant paleo intervals)	[7]Hausfather, Z., Drake, H. F., Abbott, T., & Schmidt, G. A. (2020). Evaluating the performance of past climate model projections. <i>Geophysical Research Letters</i>, 47, e2019GL085378. https://doi.org/10.1029/2019GL085378



Panel b validates our text as written: observations over the past few decades line up with the lowest ECS model. Proposed paragraphs:

The world’s several dozen global climate models offer little guidance on how the climate responds to elevated CO₂, with the average surface warming under a doubling of the CO₂ concentration ranging from 1.8°C to 5.7°C. Data-driven methods yield a lower and narrower range.

Climate models generally run “hot” in their description of the climate of the past few decades - too much warming at the surface and too much amplification of warming in the lower- and mid-troposphere. The combination of overly sensitive models and extreme scenarios for future emissions yields exaggerated projections of future warming.

I agree we should not give up so easily. As a general point, I believe there are some issues where there are legitimate differences in how to interpret things, and we are (in some sense) providing equal time for alternative explanations that the consensus tends to ignore.

viii 5,6, 7 There is very little dispute that these are challenging issues for climate science. Many of the issues identified here related to compound effects (subsidence and se-level rise; wildfire and forest management) that requires further scientific investigation. Identifying further research avenues/focus areas will be helpful to firm up some of the challenges faced in using the climate projections as discussed in the paragraph 9.
There is no disagreement here.

		I am sensing a general theme from Reviewer #1 that if he/she does not disagree with our assessment, the fall-back position is to claim that future research is needed, and the future models will be better. Which might be true, but not relevant to our review.	
viii	9	The focus on uncertainty is relevant and should be emphasized in future research. However, as a reasonable policy pathways, making decisions in the face of these uncertainties is critical. Most of the climate uncertainties that we have confidence at this time can be considered Level 2 and Level 3 uncertainties, approaches such as scenario analysis (and others) are suggested and followed for making hazard and risk estimates for future conditions. For deep uncertainty hazards (for example tornadoes etc.) that we don't have enough data or capability to model, developing methods for assessing the uncertainty and risk should be a focus of future research. There is no disagreement here. See Curry's book Climate Uncertainty and Risk.	
2	3	The reason CO2 was identified as a pollutant is the health consequences of increased temperature, flooding and other climate impacts and not because of any direct affect on health dur to exposure to atmospheric CO2[8]. There is no disagreement here.	[8] https://www.cdc.gov/climate-health/php/effects/index.html
3	1/C hapter summary	The summary should note that CO2 fertilization effects are limited by the availability of other critical plant nutrients (Nitrogen, Phosphorous). The fertilization effect is also constrained by higher temperature effecting photosynthesis[9] This issue of nutrients is addressed in Chapter 9 The Wei et al. paper goes into more detail about regional forest responses to additional CO2 than we need; our discussion is at a general level. Added sentence: Other contributing factors included warming and increased nitrogen.	[9] Xinyuan Wei et al 2025 Environ. Res. Lett. 20 064013
3	3	The attribution of greening to primarily CO2 fertilization is questionable as per recent research. Specifically, in the Northern high latitudes (where the greening is most prominent), increases in temperatures due to climate change has been shown to provide the best explanation[10]. In the sub-Saharan region reforestation efforts and changing precipitation patterns lead to some of the observed greening (the great green wall) [11]. The attribution to CO2 fertilization should be qualified by noting the other present and emerging constraints. We do not attribute the greening only to CO2 fertilization. The intent of this section is to address the role of CO2 We cite Zhu et al attributing 70% of change to CO2 . That implies other factors matter as well. Again, if warming is due to CO2, and warming is good for plants, then it's a win-win, right?	[10]Liu, J., Wennberg, P.O. An emergent constraint on the thermal sensitivity of photosynthesis and greenness in the high latitude northern forests. Sci Rep 14, 6189 (2024). https://doi.org/10.1038/s41598-024-56362-1 [11] Francesco S.R. Pausata, Marco Gaetani, Gabriele Missouri, Alexis Berg, Danielle Maia de Souza, Rowan F. Sage, Peter B. deMenocal, The Greening of the Sahara: Past Changes and Future Implications, One Earth, Volume 2, Issue 3, 2020, Pages 235-250, ISSN 2590-3322, https://doi.org/10.1016/j.oneear.2020.03.002 .
3	5	This summarization ignores the compound effects of temperature, moisture and CO2 fertilization in assessing the impacts of CO2 increase on vegetation and crop yields. Many studies have shown that [12]. Making note of these compensating factors is required for a balanced view on CO2 fertilization effects on plants. This issue is addressed in Chapter 9	[12]Lesk, C., Anderson, W., Rigden, A. et al. Compound heat and moisture extreme impacts on global crop yields under climate change. Nat Rev Earth Environ 3, 872–889 (2022). https://doi.org/10.1038/s43017-022-00368-8

4	1	Chen et al. (2024)[13] conclude that "In the attribution analysis of LAI trend and growth rate trend, there were some differences between multiple linear regression model and partial correlation analysis at high latitudes in the northern hemisphere. Partial correlation analysis showed that LAI trend and growth rate trend in this region were mainly affected by temperature and radiation, while multiple linear regression suggested that CO2 was the dominant driver. The results of the partial correlation analysis seem more reasonable because some previous studies have shown that vegetation change in the high latitudes of the northern Hemisphere is mainly positively affected by climate warming. Multiple linear regression model performed relatively poorly in this region and might not fully identify the contribution of individual drivers. In addition, our model does not include the contribution of land management, which has been highlighted in some previous studies. Of course, the contribution of land management to LAI trend and growth rate trend may be implied in other drivers, such as the positive contribution of CO2 to LAI trend in PP and PN areas". IS THIS WORTH REFERENCING? Our existing summary doesn't conflict with this. They conclude CO2 is the dominant driver globally but not the only driver. And I am inclined to put more weight on the multiple regression results than bivariate correlations.	[13]Xin Chen, Tiexi Chen, Bin He, Shuci Liu, Shengjie Zhou, Tingting Shi, The global greening continues despite increased drought stress since 2000, Global Ecology and Conservation, Volume 49, 2024, e02791,ISSN 2351-9894,
6	1	This again suffers from not acknowledging the effects of compound and often compensating phenomena that is occurring with the on-going climate change. For example [14] note that much of the Midwest any benefit from CO2 fertilization will be negated by temperature increases. [15] note that "Our results show that long-term physiological acclimation dampens the initial stimulation of plant net carbon assimilation to elevated [CO2], and of plant water use to warming." The topic of agricultural productivity is addressed in Chapter 9 It is not disputed that effects of dT go negative at high enough levels. The 2013 paper by Ruiz-Vera et al doesn't provide much general information beyond the FACE experiment site. The C14 data set I used is a global sample and takes both dT and dC into account.	[14]Ursula M. Ruiz-Vera, Matthew Siebers, Sharon B. Gray, David W. Drag, David M. Rosenthal, Bruce A. Kimball, Donald R. Ort, Carl J. Bernacchi, Global Warming Can Negate the Expected CO2 Stimulation in Photosynthesis and Productivity for Soybean Grown in the Midwestern United States , Plant Physiology, Volume 162, Issue 1, May 2013, Pages 410–423, https://doi.org/10.1104/pp.112.211938 [15] Lamba S, Hall M, Råntfors M, et al. Physiological acclimation dampens initial effects of elevated temperature and atmospheric CO2 concentration in mature boreal Norway spruce. Plant Cell Environ. 2018; 41: 300–313. https://doi.org/10.1111/pce.13079
8	1	The fallacy of these arguments in terms of PH changes and evolution is that the changes described in this paragraph occurred over millennia and the evolutionary process had time to adapt; here with climate change we are talking about changes in our lifetime, the speed of change is the issue. This will lead to collapse of some ecosystem and by the time adaptation takes place it will be millions of years and in a different climate - not the one we have now and that enabled the rise of humans. The chapter notes large regional and even diurnal variations in ocean pH. We already address the issue of short timescale variations on p. 8: "On the time scale of thousands of years, boron isotope proxy measurements show that ocean pH was around 7.4 or 7.5 during the last glaciation (up to about 20,000 years ago) increasing to present-day values as the world warmed during deglaciation (Rae <i>et al.</i>, 2018). Thus, ocean biota appear to be resilient to natural long-term changes in ocean pH since marine organisms were exposed to wide ranges in pH."	

5	Fig 2.2	A simple calculation will show us how misleading this figure is. It shows that over 600 Million years CO2 changed by around 6000ppm. That is a rate of change of 0.00001/yr; CO2 changed from 275 to 430 in the past 175 years, that is rate of change of 0.88ppm/yr. A change in the rate of over 10^5 in magnitude - there in lies the problem. We are seeing a rapid increase in CO2 that has never been witnessed and the ecosystem and huma society (which is at best 10K years old), may not be able to adapt to this rapid change. This figure addresses the evolution of photosynthesis in context of CO2 concentration We don't know what the rate of changes was on an annual or centennial time scale since the data are too low resolution. But to address the point I suggest adding the sentence “While the modern rate of change in CO2 is likely high compared to prior intervals, the geological evidence is that plants and animals evolved under much higher CO2 levels than at present.” FIGURE TO BE DELETED	
12	Summary	The misuse of RCP8.5 as business as usual is acknowledged. However, this was never intended to be a no-policy or business as usual scenario but as a high-end baseline scenario. When dealing with interaction of physical systems with socio-economic projections (which tend to be highly uncertain and policy dependent), the development of this high baseline scenarios is intended to explore the uncertainty ranges that represent a high-end scenario[16,17]. As any engineer would acknowledge, this is a prudent approach when dealing with L3 and L4 type deep uncertainties and provide valid envelopes for assessing uncertainties and risks from high impact events/hazards. The rest of the statements here are uncertainties acknowledged by the climate scientists and included in developing projections and discussing the results[4]. Does the IPCC downplay the role of sun in climate change? The IPCC includes sun variability in all its assessments from the beginning and has been acknowledged as a potential but insignificant contributor. Prudence requires giving little to no weight to implausible scenarios. Implausibility is not equivalent to very unlikely (e.g. 95th percentile), but rather includes impossible or implausible assumptions. High impact hazards occur independent of atmospheric CO2 concentrations (Chapter 6). The comments do not imply any disagreement with what we have written. Extreme scenarios for models are useful for bracketing outcomes but our criticism (based on the literature) is the widespread use of RCP as a no-policy baseline; the reviewer acknowledges that was never its purpose. The insignificance of the sun in climate change is based in part on use of irradiance reconstructions that rule out it having any role. It doesn't matter whether 8.5 was not intended to represent a BAU scenario, What matters is how widely it was used anyway.	[16]van Vuuren, D.P., Edmonds, J., Kainuma, M. et al. The representative concentration pathways: an overview. Climatic Change 109, 5 (2011). https://doi.org/10.1007/s10584-011-0148-z [17]Hausfather, Z. (2025). An assessment of current policy scenarios over the 21st century and the reduced plausibility of high-emissions pathways. Dialogues on Climate Change, 2(1), 26-32. https://doi.org/10.1177/29768659241304854 (Original work published 2025)

16	2,3,4,5	Please see above. The business-as-usual may be a misnomer but this is an 95% case that is typically included in any type of prudent uncertainty analysis, in particular given the difficulty of predicting the evolution of socio-economic and political conditions over the next 100 years. It should be noted the difference between RCP8.5 and RCP4.5 for mid-century conditions that is of particular focus for adaptation studies is not significant and most of the divergence in these two scenarios occurs later in the century. See previous response. RCP8.5 should not be regarded as a 95% case.	
19	5	That the dynamic vegetation models need more development is acknowledged and is a defining challenge for Earth System Modeling for the next decade. There is no disagreement here Correct	
22	3	As noted, Parker[18,19,20] has investigated the Urban effects on temperature records. The finding establish that by comparing warm and wind conditions world wide that the impact is negligible. However, as noted by authors, this literature hasn't progressed much over the last decade and much more attention needs to be paid to this question by employing newer models, datasets and analytical techniques available to us at present. The CWG Report addresses this concern. My 2013 paper discusses all this. I didn't include all the Parker citations in CWG25 but the topic is addressed. I agree with the reviewer that the literature stalled a decade+ ago.	[18] Parker, D. Large-scale warming is not urban. Nature 432, 290 (2004). https://doi.org/10.1038/432290a [19]Parker, D.E. (2010), Urban heat island effects on estimates of observed climate change. WIREs Clim Change, 1: 123-133. https://doi.org/10.1002/wcc.21 . [20]Parker, D. E., 2006: A Demonstration That Large-Scale Warming Is Not Urban. J. Climate, 19, 2882–2895, https://doi.org/10.1175/JCLI3730.1 .
28	2	We can all agree that there is a desperate need for developing higher-resolution climate models that can get to cloud resolving scale so that we can represent the cloud feedbacks correctly in the model and avoid uncertainties from parameterization and scale dependency of the parameters. This doesn't make these models useless. The models provide directions for further improvements and necessary changes to reduce the uncertainty bands over the ECS. The climate models are useful for research purposes. The CWG Report demonstrates that they are not fit for the purpose of policy making. We don't call the models useless, instead we assess their fitness for applications. And there's no guarantee increased resolution will be the answer, but if ever a model appears that can deal correctly with clouds that will be quite something.	

		I don't think cloud resolving models will help anyway, I was astounded to learn the ARPS model used a single, constant autoconversion threshold for cloud liquid water turning into precipitation. No microphysics at all, and no better than a GCM.	
29	2	The databased approaches have mostly been robust with changes at the high end around 3-4C and at the low end around 1.8 to 2.5C as noted in the chapter. It will be challenging to make this range shorter given the data requirements and uncertainties in data over paleo/haloacene periods. It seems reasonable to estimate that we may have ECS in the range of 3 to 4K (higher than 3.5K being less likely [21]) at the higher end and this should not prevent us from planning and thinking on ways to prevent this possible scenario as it could have major consequences for humans across the planet. The Report acknowledges that 4C is a reasonable upper bound for the likely range	[21] Michael Mann, Our Fragile Moment: How lessons from Earth's past can help us survive climate crisis, Hachette Group Inc., 2024.
32	3	The models range over a factor of three in ECS comparing the most sensitive to the least sensitive models. However vast majority of the models are in 3 to 3.5K sensitivity range and it is probably not correct to assign all models the same amount of importance, given the fact that some of institutes participating in the exercise have different levels of capacity to develop and test models. Only 5 of the models are between 3 and 3.5C Some of the most reputable models have the highest values of ECS, including UK an US models The point made in this paragraph is that research over several decades has not reduced the range of model ECS. For observers who rely on model outputs this is very concerning and again goes to the question of fitness for purpose, as posed in the prior paragraph.	
34	1	While this analysis for the CMIP6 model set is accurate and focuses on a dataset that has shown higher ECS than previous iterations. it should be noted the models have exhibited considerable skill in predicting the subsequent GMST warming[22]. The criticism of the CMIP6 based high ECS models may be premature and probably will have to wait additional time before passing judgement. As noted in [22] these models have shown considerable skill when evaluated on their projections over the past 30-40 years after the projections were published. Figure 5.3 in the Report clearly refutes this assertion Hausfather et al. did examine early model-obs matches but only using models that had relatively low ECS. The Scaffeta analysis covered a longer interval (1980-2021) than the Hausfather et al. analysis of SAR (1995-2017) and TAR (2001-2017). Its findings line up with Fig 5.3 and the tropospheric evidence in Fig 5.4.	[22]Hausfather, Z., Drake, H. F., Abbott, T., & Schmidt, G. A. (2020). Evaluating the performance of past climate model projections. Geophysical Research Letters, 47, e2019GL085378. https://doi.org/10.1029/2019GL085378

36	1	A recent study attributes the bias to inter-annual availability and residual bias in the satellite record. The pre- and post 2000 have temperature records from two separate satellites and the discrepancy in the trends needs to be resolved[23] Ref 23 is worth adding I think Chung et al. (using output through 2014 only) confirm the models' too-high warming rates and suggested two issues that might contribute to at least part of the discrepancy: (1) the differential phasing of natural, ephemeral events such as El Niños between models and observations and (2) a possible spurious cooling in UAH and NOAA/STAR satellite datasets around 2000. Regarding (1) we agree that the timing of major events like ENSOs diminishes the fidelity of models-to-observations comparisons for short periods, but now with 46 years of record as well as two major El Niño warm events since 2014 in the observations, the results shown in Fig. 5.7 are quite appropriate for comparison. Regarding (2) Christy et al. 2018 (and later Zou et al 2023) specifically examined the divergence around 2000 between UAH and NOAA/STAR vs. RSS and UW demonstrating that RSS and UW's use of the aging and drifting NOAA-14 satellite relative to the new, highly calibrated NOAA-15 sensor contributed to a spurious warming in RSS and UW. Be that as it may, CWG Fig. 5.7 is clear in noting all models overestimate the tropical temperature trend relative to observations – model trends being even more positive than those of RSS and the two Reanalyses (in addition to UAH and NOAA/STAR). Do we need to add ref [23] and a sentence to the text? I'll defer to John John has done the most detailed work on this, and don't the various satellite datasets now mostly agree with each other, especially in the tropics? Reworded. This is such an “in the weeds” issue, I'd prefer to provide these comments to the reviewer rather than go into detail in the CWG as it wouldn't change anything already stated.	[23]Chung, ES., Kim, SJ., Sohn, BJ. et al. Multi-decadal climate variability and satellite biases have amplified model-observation discrepancies in tropical troposphere warming estimates. Commun Earth Environ 5, 342 (2024). https://doi.org/10.1038/s43247-024-01510-8
38	3	This is challenge we need to face and work on improving the parametrizations. The new era of super high resolution models would resolve the complex interactions of turbulence, transport and clouds and will provide less uncertainty[24]. However, this can't be used to invalidate the entire set of models, the models are performing remarkably well given the complex system that is being modeled. It should be noted the models do cover the range of the observations and it is not outside the envelope of model predictions. The Report does not address invalidating the entire set of models. Rather we address the fitness-for-purpose of the models for policy making Fig 5.6 shows that to the extent there is a match with observations it comes from models with very little CO2 response. “However, this can't be used to invalidate the entire set of models, the models are performing remarkably well given the complex system that is being modeled.” I find this statement is not supported by the evidence unless and until “remarkably well” is metricized for us to examine and make a determination. The paper cited doesn't exactly apply to the real world (looking at Fig 1 doesn't give one much confidence in models), but does give insight into the various models as best I can tell.	[24]Merlis, T. M., Guendelman, I., Cheng, K.-Y., Harris, L., Chen, Y.-T., Bretherton, C. S., et al. (2024). The vertical structure of tropical temperature change in global storm-resolving model simulations of climate change. Geophysical Research Letters, 51, e2024GL111549. https://doi.org/10.1029/2024GL111549

40	4	Part of the problem here may be which part of the stratosphere is sampled and the importance of interannual a variabilities in the lower part of the stratosphere. [25] have shown that including the stratosphere as defined from 25 to 50km there is high confidence that the cooling signal caused by CO2 increase is detectable and beyond the noise levels of the natural and inter annual variability in the lowest part of the stratosphere. We should put this debate to rest. JOHN AND ROY? NEW SANTER PAPER NEEDS TO BE REFERENCED I've never thought that validating stratospheric temperature trends tells us anything about global warming... the stratospheric response is radiative, without cloud (or any other weather related) feedbacks that exist in the troposphere and make ECS so difficult to tie down. In short, stratospheric cooling does not validate tropospheric warming. I would vote against including it because it is misleading. Even if the models provide perfect agreement in the stratosphere, it means nothing to tropospheric feedbacks and ECS. Santer et al. examine the middle and upper stratosphere which are very sensitive to changes in composition since radiation processes provide the lion's share of forcing as Roy says. The temperature changes happen easily up there due to its tiny mass, i.e., it only takes a few added or subtracted joules to change the temperature noticeably. The 11-year solar cycle, for example, is quite clear at those altitudes (See Santer et al. Fig. 1). I don't have a problem with Santer's paper (i.e., it's not a debate), but has little relevance to the magnitude of tropospheric temperature change (i.e., the number of joules being retained in the atmosphere's bulk mass). In fact, if you look at Santer Fig. 2, they show all model TTT trends are greater than all satellite TTT trends – that's where the discrepancy is most important in terms of physics because that's where the bulk of the atmospheric mass is. Citing Santer et al. 2023 expands our document's volume but doesn't change our reported results for the troposphere where the greenhouse effect is to have its greatest impact for climate. I suppose we could cite Santer et al. 2023 as supporting our result that models are too hot in the troposphere.	[25] B.D. Santer, S. Po-Chedley, L. Zhao, C. Zou, Q. Fu, S. Solomon, D.W.J. Thompson, C. Mears, & K.E. Taylor, Exceptional stratospheric contribution to human fingerprints on atmospheric temperature, Proc. Natl. Acad. Sci. U.S.A. 120 (20) e2300758120, https://doi.org/10.1073/pnas.2300758120 (2023).
42	2	Given the large uncertainties in obtaining data over much of the Northern Hemisphere, using a smaller regional analysis to discount the models may be inappropriate. We should that this remains a question we need to resolve developing better datasets with more seasonal and sub-seasonal coverage to test the model on a global scale The reviewer's points are fine but it is important in the context of this report to point out discrepancies in the way models on some key continental-scale metrics such as, in this case, snow cover. This section directly addresses a region that is important to estimates of the Social Cost of Carbon in the context of agricultural productivity, again reiterating that the models are not fit for the purpose of policy making. Agree. Agree.	

44	3	This statement from [26] refers to the fitness of global scale models to resolve regional scale features and argues for developing model at higher spatial resolutions. Using downscaling and other techniques additional insights can be gained at regional scales and provide information for a set of 'purposes'. However, we should work on getting to regional and local scales with GCM as quickly as possible. The current model structural forms may not be adequate for resolving all of these issues merely by increasing spatial resolution. Simulating change at regional to local scales depends on getting the internal variability of the ocean correct, which is only partly a resolution issue.	
47	2	Looking for trends or estimating trends in extreme events in current and future climate is not necessarily an attribution study. Estimating frequency, duration and intensity of events helps understand the changing range of the hazard (if there is one). An attribution would be to find to what extent a particular event is influenced or affected by increase in CO2. I would consider these two not to be the same. We explain the distinction between detection and attribution	
47	3	Attributing any single event to changing climate is perilous, agreed. Yes. Agree.	
47	5	As noted by [26] there is not yet any strong evidence that LPT is a fact LPT has been used in the hydrological community for decades We cite Cohn and Lins. LTP models do a good job characterizing some types of hydrology data. Some authors argue it's an artifact of the statistical model being used. We're not taking a strong position either way, our point is (as illustrated in Fig 6.1.1) that what looks like a trend on one time scale may be part of a slow natural cycle. LTP models try to characterize long run variance allowing for this. Agree – the evidence indicates LTP is important for hydrologic/precipitation metrics.	[26]Cohn, T. A., and H. F. Lins (2005), Nature's style: Naturally trendy, Geophysics. Res. Lett., 32, L23402, doi:10.1029/2005GL024476.
57	2	I am not sure how one can conclude that the temperature extremes have decreased based on figure 6.3.4. If I understand correctly the Tmax-Tmin for each year was tabulated and a mean of this difference averaged over the 100+ years was subtracted from these values to get some thing like a anomaly. This anomaly seems to have moved from +3F to -3F over the course of q00 years and now trending upwards again. This suggests to me that there has been significant changes in the extremes over the years and the most recent trend is towards warmer highs? For each station and each year, the hottest day and coldest night are determined and their difference computed. These differences are then geographically averaged for the CONUS and then an overall average is removed to show the results as a type of anomaly. Reviewer 1 is correct, as indicated in the text, Tmin temperatures are almost universally rising more rapidly than Tmax, hence, the difference (or range) has declined overall. A check of CMIP6 models for the CONUS under ssp4.5 shows half with TMax rising faster than TMin and (obviously) half vice versa – so there is no clear signal from models that matches the observations.	

		The flattening (or slight rise in the metric) in the past 20 years is clearly within the natural range, but does reveal an interesting stair-step pattern with rapid declines centered around the 1940's and 1990's and relatively flat periods in between. An explanation is under investigation, and a leading hypothesis is that there was rapid growth of manufactured surfaces around weather stations in the 1940s. Then, in the 1960s-80s many stations were re-located to relatively rural airports, which then experienced subsequent growth in manufactured surfaces around their weather stations in the 1990s. Thus, rapid nighttime warming in the 1940s and 1990s.	
58	3	The NCA5 is suggesting that the western US is experiencing increase in extreme heat (page 57, para 4); it seems like figure 6.3.5 establishes the fact and not contradict. There was no claim of pervasive (all CONUS) increase in the report Since we will go into the NCA handling of heat extremes in detail in the NCA report I recommend we delete the sentence “The NCA5 heading “The Risk of Temperature Extremes is Changing” suggests pervasive positive trends are now being observed in threshold temperatures, but that is not evident in the figures above.”	
59	4	The definition of heat wave as consecutive 6 days seems to be a special case. The standard definition is exceedance of 85 or 90 percentile for 2 or more days. I can't check with NCA5 as it was taken down from the web As correctly suggested by Reviewer 1, there are numerous ways to define a heat wave. CWG chose to follow one definition discussed in NCA4 (pg 191) and use 6 consecutive days with Tmax > 90th percentile so as to allow for consistent comparisons. However, changing the parameters will do little to alter the fundamental result that the 1920's to early 1950's contain the major heat wave events for the CONUS.	
60	1,2	Figure 6.3.6 establishes that heatwaves as defined here have increased in the west and have shown increasing trend all over CONUS in the past 50 years. [27] shows the results for the last 60 years and there is little doubt that there is an increase over most of the CONUS, again the NCA5 report is off the web; figure 6.3.7 shows the heat waves are monotonically increasing from the 1960. Including the longer data is only interesting in the dust bowl 1930 camouflage the signal somewhat for the Midwest and central plains. The problem of taking averages over large regions (for example entire CONUS) is that it kills the peak signals and smooths out the emergent climate change indicators. Doing continental averages to look for extremes is really not very useful. Secondly, there is no particular reason to assume that the climate change signal (i.e. the number of heat waves) should showing up 100 years ago, as the CO2 in the atmosphere started to be of significance in the last 50 years. As discussed in the CWG text, the EPA chart is (1) based on nighttime temperatures in the 50 largest US cities and (2) begins in 1961 which was the start of the coolest decade in over 100 years, thereby preconditioning the chart to have an upward trend. Urbanization is most clearly seen in nighttime temperature increases so this does not represent a change in the background climate, but more likely the local climates of cities. Rural areas show less nighttime warming. And, avoiding earlier warm periods does not provide information on the larger scale of natural variability.	[27]https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves

		The point about the GHG signal is that the lack of trend in the Central-East argues against simple attribution. I suggest adding a sentence at the end of Section 6.3 “Irrespective of the ultimate cause of regional trends, heatwaves have important effects on society which must be addressed, as we discuss in Chapter 10. “ (Doesn’t affect pagination) Agree	
61	4	averaged over all stations in the region, none of these trend parameters is statistically significant'. This is again how one would be looking at statistics of extremes in precipitation. As we know, precipitation is highly heterogenous and location dependent. As observed there are trends even with the approaches chosen by the authors of this study compared to NCA5 and averaging that over and saying there is no trend seems disingenuous. We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area.	
62	2	same argument as above We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area.	
63	box	again the issue here is that we are talking about events that are happening in a short-time and over a small region. Averaging over time and space and develop statistics is probably not appropriate when we are talking about events such as the recent flooding event in Texas. If you average that event over 30 days, it will seem unremarkable. Extreme event totals are 1-day to 5-days depending on section discussed. The point being made in the Box is that if you use a too-short record you may underestimate natural variability. I’m not sure how the reviewer’s comment challenges this. Since we are looking at short-term events in this box (3-days and up), an event in Texas would be captured by such temporal resolution. We are in the process of building a precipitation dataset of the Texas Hill Country to determine more precisely how such short-term events have fluctuated since at least 1893. I believe in our NCA5 Review we tested the Austin TX time series for changes in events and found nothing significant.	

64	1	As noted in NCA5 and shown in the analysis presented in figure 6.4.4 there is a clear trend of increase in extreme precipitation in 12 of the 27 stations analyzed. Again averaging over the entire region is not the best method for picking extreme precipitation events that are local both in time and space. We summarize the site-specific trends as well as the regional average. The rationale for looking at the regional average is that a GHG signal should cover a wide area. Also in this case we point out that the NE behaves differently than other regions.	
69	2	However, there is evidence that flash droughts, which last weeks have increased over the Northeast and Midwest [28] The paper referenced by Reviewer 1 begins with data so recent (1999) that it cannot provide evidence for long-term changes in drought as evidenced in the US Drought Monitor (DM) even though it suggests an increase in "flash droughts" over that period. Keep in mind, the DM is a product of subjective interpretation and objective measures - objective measures that have changed considerably during the past 25 years – thus is not metrically consistent. (One of the CWG authors was an official contributor to the DM for 15 years.) One would wonder what would the 1920's. 30's and early 50's reveal if the DM was operational back then? A more consistent metric is provided in CWG Fig. 6.7.1. WHAT IS DM? Drought Monitor, a NOAA product. Reworded.	[28]Ronald D. Leeper, Rocky Bilotta, Bryan Petersen, Crystal J. Stiles, Richard Heim, Brian Fuchs, Olivier P. Prat, Michael Palecki, Steve Ansari
70	2	More recent analysis indicate forest loss due to wildfire accelerating over the recent past[29]. In particular there has been an increase in extreme fire radiative power with a 2 fold increase from 2003 to 2023 (period of satellite data availability)[30][31]. However, that these fires are not out-of-sample and there is a fire deficit as shown in figure 6.8.2 should be acknowledged. But this doesn't alleviate the concern that wildfire is leading to lot of socio-economic concerns and needs to be addressed[32] Suggest adding sentence after Samborska and Ritchie citation: However there is evidence that the intensity of fires in some regions is worsening (Cunningham et al. 2024) and that wildfires resulted in a net loss of global forest cover over 2001-2019 (Tyukavina et al. 2022). This + references don't change pagination	[29]Tyukavina Alexandra , Potapov Peter , Hansen Matthew C. , Pickens Amy H. , Stehman Stephen V. , Turubanova Svetlana , Parker Diana , Zalles Viviana , Lima André , Kommareddy Indrani , Song Xiao-Peng , Wang Lei , Harris Nancy; Global Trends of Forest Loss Due to Fire From 2001 to 2019, Frontiers in Remote Sensing.Volume 3 – 2022,2022. [30]Cunningham, C.X., Williamson, G.J. & Bowman, D.M.J.S. Increasing frequency and intensity of the most extreme wildfires on Earth. Nat Ecol Evol 8, 1420–1425 (2024). https://doi.org/10.1038/s41559-024-02452-2 [31]Patrick H. Freeborn, W. Matt Jolly, Mark A. Cochrane, Gareth Roberts, Large wildfire driven increases in nighttime fire activity observed across CONUS from 2003–2020, Remote Sensing of Environment, Volume 268, 2022,12777 [32]Parks, S.A., Guiterman, C.H., Margolis, E.Q. et al. A fire deficit persists across diverse North American forests despite recent increases in area burned. Nat Commun 16, 1493 (2025). https://doi.org/10.1038/s41467-025-56333-8
71	3	The question of forest management and its role on wildfire frequency and intensity is interesting and deserves further study. We agree ...again, do “further study” and “better models” justify accepting past studies and models? I feel like this is what is being implied...	

80	1	The global mean sea-level was increasing at a rate of 0.08 inches/yr in 1993 compared 0.18 inches/yr in 2023, almost double the rate[33], which is approximately what is needed to meet the NOAA projections by mid-century and seems plausible. STEVE?	[33]Hamlington, B.D., Bellas-Manley, A., Willis, J.K. et al. The rate of global sea level rise doubled during the past three decades. Commun Earth Environ 5, 601 (2024). https://doi.org/10.1038/s43247-024-01761-5
88	3	A possible reason the method used by IPCC (optimal fingerprinting) can be considered to address McKitnick criticism is in [34] We cite Chen et al. They mostly just reiterate my points. They propose a resolution to one part of the problem but it requires very restrictive assumptions.	[34]Chen, H., Chen, S.X. & Mu, M. A statistical review on the optimal fingerprinting approach in climate change studies. Clim Dyn 62, 1439–1446 (2024). https://doi.org/10.1007/s00382-023-06975-5
92	4	The role of clouds remains the single most uncertainty in climate modeling, I am glad this was acknowledged here. Agreed	
93	3	The substance of this paragraph was addressed in my comments in earlier sections. Some of the claims made here are either exaggerations of the usual practice (RCP8.5 being referred to as BAU) or the comment about not fit for purpose (a comment extracted from a publication that is calling out for cloud resolved models. Presumably the reviewer agrees RCP8.5 should not be used as a BAU scenario, so we are in agreement. The Palmer and Stevens paper nonetheless says the models are not currently fit for purpose.	
105	2,3, 4,5	The problem with both the FACE studies and the soybean. Maize and wheat studies cited here are that they don't consider the effect of increase in temperature, changes in precipitation, humidity and other environmental factors along with CO2 increases. These compound effects have been shown in wide number of studies [35] [36][37][38][39]. A meta analysis of the compound effects shows that increase in CO2, along with temperature, precipitation changes effects the quality of the cereal and yields[40]. Another recent study evaluated the impacts on C3 and C4 crops and conclude that CO2 enrichment for C3 crops could increase but will be compensated by temperature increase. CO2 fertilization effect was found to be small for C4 [41]. It is important therefore that we consider the compound effects on crop yields and not just focus on CO2 enrichment. The reviewer is correct that compound effects need to be considered, and indeed one of the problems with a lot of econometric papers on climate change and agriculture is they only look at heat and ignore the CO2 enrichment (Taylor and Schlenker being an important exception). Since our remit was impacts of CO2 emissions a brief discussion of FACE plot experiments and other CO2-only experiments is on topic. We discuss meta-analysis of multivariate (compound) experiments in Section 9.3.	[35] Ruiz-Vera UM, Siebers M, Gray SB, Drag DW, Rosenthal DM, Kimball BA, Ort DR, Bernacchi CJ. Global warming can negate the expected CO2 stimulation in photosynthesis and productivity for soybean grown in the Midwestern United States. Plant Physiol. 2013 May;162(1):410-23 [36] Levine LH, Richards JT, Wheeler RM. Super-elevated CO2 interferes with stomatal response to ABA and night closure in soybean (Glycine max). J Plant Physiol. 2009 Jun 1;166(9):903-13. [37]Večeřová K, Oravec M, Puranik S, Findurová H, Veselá B, Opoku E, Ofori-Amanfo KK, Klem K, Urban O, Sahu PP. Single and interactive effects of variables associated with climate change on wheat metabolome. Front Plant Sci. 2022 Oct 10;13:1002561. [38]Thomas, J.M.G., Boote, K.J., Allen, L.H., Gallo-Meagher, M. and Davis, J.M. (2003), Elevated Temperature and Carbon Dioxide Effects on Soybean Seed Composition and Transcript Abundance. Crop Sci., 43: 1548-1557. https://doi.org/10.2135/cropsci2003.1548 [39] Lesk, C., Anderson, W., Rigden, A. et al. Compound heat and moisture extreme impacts on global crop yields under climate change. Nat Rev Earth Environ 3, 872–889 (2022). https://doi.org/10.1038/s43017-022-00368-8 [40] Ben Mariem S, Soba D, Zhou B, Loladze I, Morales F, Aranjuelo I. Climate Change, Crop Yields, and Grain Quality of C3 Cereals: A Meta-Analysis of [CO2], Temperature, and Drought Effects. Plants. 2021;

			10(6):1052. https://doi.org/10.3390/plants10061052 [41]Rezaei, E.E., Webber, H., Asseng, S. et al. Climate change impacts on crop yields. Nat Rev Earth Environ 4, 831–846 (2023). https://doi.org/10.1038/s43017-023-00491-0
106	1	Taylor and Schlenker 2021 also note that 'Climate change will likely have negative impact on agriculture in aggregate, especially in regions exposed to extreme heat. And the CO2-driven yield increases may be offset by effects on food nutrition and quality'. However, the results for US have been a net positive in the recent past but not true in the lower latitudes. Extreme heat may be a net negative, but thus far the overall effects have been positive. Regarding nutrition loss see Section 9.4	
111	1,2	The criticism of NOAA Billion dollar map is likely warranted as it was never completely transparent how the data was generated. However, changing the baseline assumption and refactoring the data using a different set of criteria to make the effects smaller also doesn't make sense. We should continue collecting this data and make the data accessible for researchers and peer review. Figure 10.1 doesn't address these issues, it is another methodology with unknown provenance of the data. We agree that data collection, dissemination and transparency are key. Fig 10.1 is traceable as an indicator though we don't regard it as the final word on the subject either. Again, we should not get sidetracked by things that were not part of our charge.	
117	3	Climate change can be expected to increase cold weather extremes in regions that have not been exposed to these effects ????? Not sure what the reviewer's point is. There is no citation – just a claim – so no response can be made.	

118	3	The same Nobel prize winning model in its most recent study concludes that [42] "We conclude with three results relevant for climate policy. First, both current policies (base run) and the extended Paris Accord fall short of limiting global warming to 2 °C or to the cost–benefit optimal level. Second, the economic stakes in global climate policy are substantial, with estimated net present value of economic benefits around \$120 trillion from the cost–benefit optimal policy. Third, once differences in discounting are considered, the baseline DICE-2023 estimate of the social cost of carbon (\$66/tCO₂ for 2020) aligns closely with other recent estimates". Obviously this is the latest and the current version of the model and these results are quite different from thus discussed on this page. These conclusions should also be included in this discussion to avoid selective reading of the literature. We discuss Barrage and Nordhaus (2024) on p. 121.	[42]L. Barrage, & W. Nordhaus, Policies, projections, and the social cost of carbon: Results from the DICE-2023 model, Proc. Natl. Acad. Sci. U.S.A. 121 (13) e2312030121, https://doi.org/10.1073/pnas.2312030121 (2024).
120	1	Similar empirical studies [43] point to "Using an empirical approach that provides a robust lower bound on the persistence of impacts on economic growth, we find that the world economy is committed to an income reduction of 19% within the next 26 years independent of future emission choices (relative to a baseline without climate impacts, likely range of 11–29% accounting for physical climate and empirical uncertainty). These damages already outweigh the mitigation costs required to limit global warming to 2 °C by sixfold over this near-term time frame and thereafter diverge strongly dependent on emission choices. Committed damages arise predominantly through changes in average temperature, but accounting for further climatic components raises estimates by approximately 50% and leads to stronger regional heterogeneity. Committed losses are projected for all regions except those at very high latitudes, at which reductions in temperature variability bring benefits. The largest losses are committed at lower latitudes in regions with lower cumulative historical emissions and lower present-day income". This study uses more of the daily temperature precipitation from 1600 hundred locations world wide instead of global means. There are numerous studies that show the cost, many described in the COP 21 and follow-on meetings The Kotz et al. paper is subject to a cautionary notice at the Nature website that “the reliability of data and methodology presented in this manuscript is currently in question.” https://www.nature.com/articles/s41586-024-07219-0 The literature showing growth effects of temperature increase is pretty robust. And though we don’t cite it, there is a new paper just accepted at Climate Change Economics by me and Devina Lakhtakia adding to the evidence using 2 newly-constructed global data bases.	[43] Kotz, M., Levermann, A. & Wenz, L. The economic commitment of climate change. Nature 628, 551–557 (2024). https://doi.org/10.1038/s41586-024-07219-0

Page	para	Comment or Suggested Edit
		The report indicates numerous examples of uncertainties in climate science. It would be extremely helpful if these uncertainties were made more explicit, listed in a concluding section, and prioritized in some way - what are the top 10 priority research areas? If the opening remarks by Secretary Wright and the title pointed to uncertainties and the need for more research, I believe this report will be better received. As I read the report and left review comments below, I bolded items where I gather the authors imply that research is needed . Consider including these kinds of statements throughout and adding a summary.
viii	3	This would be more correct: "Some scenarios of future CO2 emissions overestimate observed levels" Already fixed
viii	5	This would be more correct: Some detailed climate models run "hot" in their simulation of the climate of the past few decades, while many have underestimated the amount of surface warming. More research is needed to select the most skillful and reliable models. DON'T ADD THIS. NONE ARE SKILLFUL OR RELIABLE
viii	6	Need reference for: "Claims of increased frequency or intensity of hurricanes, tornadoes, floods, and droughts are not supported by historical data." More research is needed to identify how frequency and intensity of weather events are affected by environmental conditions Not needed, this is a weather issue.
4ff		It is misleading to separate the photo-chemical effects of CO2 from the temperature effects. Extreme heat is hard on plants, causing them to lose water, close stomata, etc. It depends on the plant and the degree of heat. More research is needed to understand how the temperature (mean and variability) affects plant productivity and resilience. NOT NEEDED
7		Again it is misleading to separate the CO2 and the temperature effects on the oceans. The warming surface waters is having significant impact on ocean fish and habitats due to the overall increase in global temperatures The section is on direct CO2 effects
14	4	More accurate to say "because their effect remain largely unknown". Good examples include natural aerosols (sea salt, dust, biogenic aerosols). Are there others to mention? More research is needed to understand radiative effects of both natural and anthropogenic sources of radiative variability throughout the atmospheric column. NOT NEEDED. RADIATIVE EFFECTS ARE WELL UNDERSTOOD
17	figure	What scenarios are the models using in this figure? AGREED THAT FIG 3.2.1 needs clarification in caption
19		Vegetation is only one way that CO2 is accommodated by land processes, the other is through soils and microbial processes Microbial dynamics is complex and challenging to understand but may also be a way to boost CO2 absorption by soils (which also enriches the soil nutrients!). More research is needed to better understand how plants and soil systems remove CO2 from the atmosphere. MAYBE ADD THIS STATEMENT
19	5	More research is needed to improve the understanding and representation of land systems, carbon and nutrient fluxes in models. OK to add this statement

20		Carbon uptake by oceans and ocean ecosystems is less well studied and modeled. The lack of spread of carbon in ocean models may result from insufficient information, ocean biogeochemistry, ecosystems and model development. More research is needed to study and model carbon, nutrient and ecosystem processes and dynamics in ocean models. OK TO ADD THIS STATEMENT
		More research is needed to map warming trends in urban, non-urban and other environments and to ensure accurate representation of regional and global trends in temperature. A statement something like this is ok
27	2	"This practice" - need to clarify whether this refers to "emergent property" or discarding. I believe the authors mean the latter, but it should be made more clear I think our statement is ok as is
27	3	"assumed positive cloud feedback" - this is an emergent property too, based on simulation/observation. Should be rephrased to not use the word "assumed". Further research is needed to better understand and model how clouds change with temperature and what the feedback effects are on the radiative balance. Agree to delete the word assumed.
		Further research is needed to narrow the uncertainty on climate sensitivity, both using models and observations. Statement not useful, further research isn't going to help this.
33		The text and figure refer to 33 models, which would include the best and worst. How much does the uncertainty/range change for a subset of best-performing models? There is no generally agreed upon metric for best performing models
34	figure	How many models are included in each case? NEEDS CLARIFICATION
36	figure 5.4	How are the lower and mid-troposphere defined? If you have to ask, the definition won't be very meaningful
37	4	"excess amplification" - amplification of what? And Figure 5.6 shows tropics, is this bias only tropical? Needs clarification
38		Further research is needed to improve how models represent clouds and dynamics; additional observations are also needed to improve these representations. We don't need to state this.
42		Further research is needed to improve how models represent planetary albedo to align with observations. Not a useful statement
		The greater concern with hurricanes is the amount of moisture they carry and drop after landfall, i.e. flooding. While this is an active area of research, it is worth noting that this may be the bigger issue for hurricane change with warming I could add a statement regarding rainfall and storm surge
56-57		The concern for many are the extreme hot temperatures without night-time cooling that provides an opportunity for recovery. This section doesn't address this. In this regard, the focus on the difference between extreme hot and extreme cold is misleading when generalizing about decrease in extremes (figure 6.3.4) - the decrease is because we don't have as much extreme cold.

		Worth adding a statement
60		Combining heat and humidity as a measure of extreme heat is not unusual since it is this combination that is most impactful to human health - the body cannot cool if the humidity and heat are both high. Since a warmer atmosphere holds more moisture, and CO2 causes heat (and therefore moisture) to increase, this combination is a relevant assessment of the effects of CO2 on extreme conditions that make it difficult for people. Also combining with urban regions is helpful since that is where most people live. These points are not made in the report and are important. Worth commenting on, but the air is pretty dry in western US where CO2 might be having an impact on heat extremes
		Patterns and variability of precipitation are poorly understood and models are particularly challenged to represent and predict precipitation, further research in this area is needed Not a useful statement
		The authors rightly describe the extreme uncertainty regarding sea level rise. It would be helpful to add some information about the complex, highly nonlinear and uncertain processes involved with ice-sheet dynamics and ice-sheet - ocean interactions that are especially key for Antarctica. More research is needed to study and model ice sheet dynamics and ice-sheet ocean interactions. I could add something about this
84	3	Further research is needed on climate variability, effects of ocean circulation, solar variability, model simulation of variability and statistical methods. These are the words of a program manager who wants to increase research budgets
87-88		Anthropogenic aerosol effects may also influence the inflections in temperature in ways that are challenging to account for
91	2 and 3	Reductions in aerosol indirect (cloud brightening) effects may also explain the reduced planetary albedo, not just from ships but from reduced fossil fuel aerosols coming from the continents, China and east asia especially. This paper describes the reduction in aerosols https://www.nature.com/articles/s41612-023-00488-y This is another area that needs further research! Not really, but a sentence or two could be added
94	table 8.1	What are the numbers in the 3rd column? Please include in the caption.
95	2	I don't see an inconsistency between what Ch 11 and Ch 8 say. The first is about precipitation, droughts, tropical cyclones, heat - overall. The 2nd (ch 8) is about specific types of events in specific regions. Suggest to soften the statement about the contrasting assertions.
		The science of attribution of extreme events is challenging and computationally expensive; this is an area where further research is needed with potential to use AI to improve statistics NOPE.
104		This section seems to gloss over many key points. Certainly there are limits where extreme heat and drought (water is key) could be detrimental to crops. It also depends on which crops. There is extensive literature on how certain crop viability is shifting. So a region with particular crop experience and cultivation may no longer be able to sustain that agriculture. There is cost to shifting crops across regions and farmers that needs to be accounted for. And water is key - is there enough water in various regions for energy (power plants need water) as well as agriculture when conditions are very hot for sustained periods?

111		Severe weather continues to disproportionately impact lower income communities as well as business that requires outdoor exposure. A thorough analysis would need to include these points and I recommend adding this caveat to the section. NOPE
		Related to my previous comment, deaths due to extreme heat conditions appear to be increasing, particularly for certain populations and for those with underlying health conditions (which can be hard to detangle when attributing mortality). For example https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2792389 NOPE, we aren't going there
114		An additional concern is if the grid fails under either extreme heat demands or cold/severe-storm events, the impact on communities will not be uniform and depends on grid infrastructure which can be better in more affluent communities Nope we aren't going there
		The impacts of sea level rise and coastal inundation on coastal communities and in low-lying countries should be addressed. This will have impacts particularly on certain countries/regions but also on world economics Focusing here on US
		Research is needed to better understood the likelihood and impacts of various tipping points, including changes to ocean circulation patterns, ice sheet acceleration, sea-ice loss, die-off of tropical forests, thawing of permafrost, etc NOPE. .
		Do the authors think it worthwhile for private or public research, such as at DOE, to seek breakthrough technology that might effectively remove massive amounts of CO2 from the atmosphere?

Page	para	Comment or Suggested Edit
		The report indicates numerous examples of uncertainties in climate science. It would be extremely helpful if these uncertainties were made more explicit, listed in a concluding section, and prioritized in some way - what are the top 10 priority research areas? If the opening remarks by Secretary Wright and the title pointed to uncertainties and the need for more research, I believe this report will be better received. As I read the report and left review comments below, I bolded items where I gather the authors imply that research is needed. Consider including these kinds of statements throughout and adding a summary. An interesting suggestion but with the time constraints I suggest this be deferred to a separate report.
viii	3	This would be more correct: "Some scenarios of future CO2 emissions overestimate observed levels" It would also convey less information since it would be consistent with the average corresponding to observed. The point we are making is that the bulk of the scenarios have overstated observed trends.
viii	5	This would be more correct: Some detailed climate models run "hot" in their simulation of the climate of the past few decades, while many have underestimated the amount of surface warming. More research is needed to select the most skillful and reliable models. The need for more research on model development is implicit. Again, this would be a good topic for a separate report.
viii	6	Need reference for: "Claims of increased frequency or intensity of hurricanes, tornadoes, floods, and droughts are not supported by historical data." More research is needed to identify how frequency and intensity of weather events are affected by environmental conditions. The ES statements are all supported by the document chapters <u>but suggest we add references to specific sections.</u>
4ff		It is misleading to separate the photo-chemical effects of CO2 from the temperature effects. Extreme heat is hard on plants, causing them to lose water, close stomata, etc. It depends on the plant and the degree of heat. More research is needed to understand how the temperature (mean and variability) affects plant productivity and resilience. 1st paragraph of Section 2.1, <u>suggest</u> adding sentence "Here we focus just on CO2 fertilization; research on combined effects due to temperature and precipitation changes are discussed in Chapter 10."
7		Again it is misleading to separate the CO2 and the temperature effects on the oceans. The warming surface waters is having significant impact on ocean fish and habitats due to the overall increase in global temperatures This section is specifically on changing alkalinity. We haven't included a review of temperature effects on fish populations: it is one of the impacts topics we were not able to survey.
14	4	More accurate to say "because their effect remain largely unknown". Good examples include natural aerosols (sea salt, dust, biogenic aerosols). Are there others to mention? More research is needed to understand radiative effects of both natural and anthropogenic sources of radiative variability throughout the atmospheric column. Agreed, <u>suggest</u> sentence read "Natural sources of global energy imbalance other than volcanoes and total solar irradiance (TSI) are not included in these graphs because their effects remain largely unknown."
17	figure	What scenarios are the models using in this figure? SRES, as stated in text, also others including Hansen A,B,C and others as described in the Hausfather et al. paper.

19		Vegetation is only one way that CO2 is accommodated by land processes, the other is through soils and microbial processes Microbial dynamics is complex and challenging to understand but may also be a way to boost CO2 absorption by soils (which also enriches the soil nutrients!). More research is needed to better understand how plants and soil systems remove CO2 from the atmosphere. Noted.
19	5	More research is needed to improve the understanding and representation of land systems, carbon and nutrient fluxes in models. Noted.
20		Carbon uptake by oceans and ocean ecosystems is less well studied and modeled. The lack of spread of carbon in ocean models may result from insufficient information, ocean biogeochemistry, ecosystems and model development. More research is needed to study and model carbon, nutrient and ecosystem processes and dynamics in ocean models. Noted.
		More research is needed to map warming trends in urban, non-urban and other environments and to ensure accurate representation of regional and global trends in temperature. Noted.
27	2	"This practice" - need to clarify whether this refers to "emergent property" or discarding. I believe the authors mean the latter, but it should be made more clear Suggest rewriting sentence: "Parameter tuning to yield an ECS target was commonplace for the models used in AR4; modelers have moved away from this practice with time."
27	3	"assumed positive cloud feedback" - this is an emergent property too, based on simulation/observation. Should be rephrased to not use the word "assumed". Further research is needed to better understand and model how clouds change with temperature and what the feedback effects are on the radiative balance. Need to clarify if cloud feedbacks are assumed, imposed or both? Can be handled editorially by deciding whether to delete "assumed" or not; deleting it allows it to remain as an implicit modifier.
		Further research is needed to narrow the uncertainty on climate sensitivity, both using models and observations. Noted.
33		The text and figure refer to 33 models, which would include the best and worst. How much does the uncertainty/range change for a subset of best-performing models? My speculation is that the modeling community doesn't have a leaderboard of best-to-worst models. Everyone knows the Canadian model is way too hot but it still gets used because it has some features people find useful. In principle with so many models you could pick a target metric like surface temperature and select the models that do best against it post hoc (as in the scaffeta analysis), but that doesn't guarantee those models will do the best at representing something else like precipitation patterns or a paleo episode.
34	figure	How many models are included in each case? High ECS 14, Medium ECS 11, Low ECS 13. Suggest this be added to Figure caption.
36	figure 5.4	How are the lower and mid-troposphere defined? Standard definitions in the paper: LT surface to ~9km, MT surface to ~15 km. Stated in the paper, not sure it needs to be in the Fig caption.
37	4	"excess amplification" - amplification of what? And Figure 5.6 shows tropics, is this bias only tropical? Suggest sentence read "Another important model-observational discrepancy is the excess amplification or warming with altitude..." The bias is only observed in the tropics but the amplification pattern is only predicted in the tropics. Also bear in mind the tropics is nearly half the atmosphere

		and is where most solar energy enters the climate system.
38		Further research is needed to improve how models represent clouds and dynamics; additional observations are also needed to improve these representations. Noted.
42		Further research is needed to improve how models represent planetary albedo to align with observations. Noted.
		The greater concern with hurricanes is the amount of moisture they carry and drop after landfall, i.e. flooding. While this is an active area of research, it is worth noting that this may be the bigger issue for hurricane change with warming This is covered in the AR6 assessment as quoted, as it's one of the intensity metrics. Currently too little data to assess for trends.
56-57		The concern for many are the extreme hot temperatures without night-time cooling that provides an opportunity for recovery. This section doesn't address this. In this regard, the focus on the difference between extreme hot and extreme cold is misleading when generalizing about decrease in extremes (figure 6.3.4) - the decrease is because we don't have as much extreme cold. This metric is (I think) covered by the data in Sct 6.3.3.
60		Combining heat and humidity as a measure of extreme heat is not unusual since it is this combination that is most impactful to human health - the body cannot cool if the humidity and heat are both high. Since a warmer atmosphere holds more moisture, and CO2 causes heat (and therefore moisture) to increase, this combination is a relevant assessment of the effects of CO2 on extreme conditions that make it difficult for people. Also combining with urban regions is helpful since that is where most people live. These points are not made in the report and are important. Suggest sentence be changed to read: "Given the heatwave definition and urban focus, while these increasing values since 1960 point to a growing human impact they are not informative about long term trends or..." Along with newly-added sentence at end of paragraph (Irrespective of the ultimate cause of regional trends, heatwaves have important effects on society which must be addressed, as we discuss in Chapter 10.) this should address reviewer concerns.
		Patterns and variability of precipitation are poorly understood and models are particularly challenged to represent and predict precipitation, further research in this area is needed Noted.
		The authors rightly describe the extreme uncertainty regarding sea level rise. It would be helpful to add some information about the complex, highly nonlinear and uncertain processes involved with ice-sheet dynamics and ice-sheet - ocean interactions that are especially key for Antarctica. More research is needed to study and model ice sheet dynamics and ice-sheet ocean interactions. Noted. Canvassing ocean dynamics in that much detail beyond our scope but would belong in a separate report.
84	3	Further research is needed on climate variability, effects of ocean circulation, solar variability, model simulation of variability and statistical methods. Noted.
87-88		Anthropogenic aerosol effects may also influence the inflections in temperature in ways that are challenging to account for Noted.
91	2 and 3	Reductions in aerosol indirect (cloud brightening) effects may also explain the reduced planetary albedo, not just from ships but from reduced fossil fuel aerosols coming from the continents, China and east Asia especially. This paper describes the reduction in aerosols https://www.nature.com/articles/s41612-023-00488-y This is another area that needs further research! Noted.

94	table 8.1	What are the numbers in the 3rd column? Please include in the caption. Good point. <u>Suggest</u> adding to caption: “Numbers refer to footnotes in original source that specify locations or region-specific confidence levels.”
95	2	I don't see an inconsistency between what Ch 11 and Ch 8 say. The first is about precipitation, droughts, tropical cyclones, heat - overall. The 2nd (ch 8) is about specific types of events in specific regions. Suggest to soften the statement about the contrasting assertions. Sentences at issue are “Evidence of observed changes in extremes and their attribution to human influence (including greenhouse gas and aerosol emissions and land-use changes) has strengthened since AR5, in particular for extreme precipitation, droughts, tropical cyclones and compound extremes” versus “No evidence of emergence in the historical period of a change in river floods, heavy precipitation, drought, fire weather, severe wind storms, and tropical cyclones”. It seems apparent to me that these statements are in conflict.
		The science of attribution of extreme events is challenging and computationally expensive; this is an area where further research is needed with potential to use AI to improve statistics Noted. Not sure about the computationally intensive point: many just run univariate GEV models and overinterpret the results. AI won't fix the bad methodology.
104		This section seems to gloss over many key points. Certainly there are limits where extreme heat and drought (water is key) could be detrimental to crops. It also depends on which crops. There is extensive literature on how certain crop viability is shifting. So a region with particular crop experience and cultivation may no longer be able to sustain that agriculture. There is cost to shifting crops across regions and farmers that needs to be accounted for. And water is key - is there enough water in various regions for energy (power plants need water) as well as agriculture when conditions are very hot for sustained periods? The comment seems to be about the validity of the underlying literature rather than our summary of it. The econometric lit tries to synthesize patterns over large areas to get at overall trends, rather than the agronomy focus on specific sites and crops.
111		Severe weather continues to disproportionately impact lower income communities as well as business that requires outdoor exposure. A thorough analysis would need to include these points and I recommend adding this caveat to the section. This is specifically addressed in Section 10.3.2
		Related to my previous comment, deaths due to extreme heat conditions appear to be increasing, particularly for certain populations and for those with underlying health conditions (which can be hard to detangle when attributing mortality). For example https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2792389 Again this topic is specifically addressed in Section 10.3.2
114		An additional concern is if the grid fails under either extreme heat demands or cold/severe-storm events, the impact on communities will not be uniform and depends on grid infrastructure which can be better in more affluent communities Good point. We don't discuss what makes for grid stability versus instability, especially in the context of many jurisdictions closing reliable power plants and opting for intermittent renewables, but the correlation between extreme weather and the likelihood of power failure is an important topic.
		The impacts of sea level rise and coastal inundation on coastal communities and in low-lying countries should be addressed. This will have impacts particularly on certain countries/regions but also on world economics Good point. The topic is germane but runs into the limits of what we can cover in our limited time. To some extent it is covered in the economics chapter since IAM damage functions include effects of sea level rise on coastal areas.
		Research is needed to better understood the likelihood and impacts of various tipping points, including changes to ocean circulation patterns, ice sheet acceleration, sea-ice loss, die-off of tropical forests, thawing of permafrost, etc. Noted. Hopefully our discussion clarifies the different types of “tipping point” topics.

		Do the authors think it worthwhile for private or public research, such as at DOE, to seek breakthrough technology that might effectively remove massive amounts of CO2 from the atmosphere? RM Personally: sure if private firms want to look into it that's ok (as long as they don't simply become lobbyists for uneconomic mitigation systems). As for public money I'd prefer it be spent on searching for a low-cost CO2 scrubber for power plants.
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Chapter Number	Page Number	Approximate Paragraph Number	Comment or Suggested Edit
	i		In general, criticism and re-analysis of past research is always welcome. This report summarizes some substantial concerns from a small group of researchers. The report should be reframed to reflect this and I provide some suggestions in a later comment. I suspect that simply publishing this report will not offset the hundreds of reports and publications on CO2 and Climate that have come before it. But, new analyses and communication within and outside the research community could make a positive difference, should the findings in this report be substantiated. The DOE Office of Science BER could be provided an opportunity to address the research uncertainties in this document in a thorough and robust manner. Noted.
	iii	1	As someone who used to read the DOE reports on CO2 as a graduate student in the 1990s and then conducted numerous analyses of carbon on many topic areas which were later confirmed by numerous other analyses, it seems somewhat cavalier for DOE to issue one brief conclusive report on the "impacts of carbon dioxide emissions". I suggest the following option: Change the title to "Topics of Uncertainty on the Impacts of Carbon Dioxide Emissions on the U.S. Climate" or " An Assessment of CO2 Impacts on Climate to Guide Future Research ", and then use this report to drive research/analyses for each report chapter which would conclude in separate topical reports that could be finished within a year or two. In doing so, the DOE would positively contribute to addressing some of these standing issues and hopefully enable the nation to move forward in a more productive manner. Noted. <u>Suggest</u> "A Critical Assessment of the Impacts of Carbon Dioxide Emissions on U.S. Climate."
	vii	Forward	I appreciate the perspective. It could be useful to add or edit the Secretary's Forward to indicate that " the report has been purposefully commissioned to researchers with alternative perspectives in an effort to address these perspectives and provide some closure for the American public, the US Economy, and US energy policy. " I suggest this, because it will be very obvious that a handful of skeptics were chosen out of literally hundreds of extremely active and well-respected scientist. Addressing that upfront will immediately reduce criticism, and hopefully generate a positive environment to address these issues. Everyone would like to see convergence of findings on these issues. Noted. The suggested sentence is not well-phrased, but the reviewer is correct that everyone will see the names and know that the document is coming from a particular perspective. The problem is no such concerns were expressed when people with known biases got put in charge of NCA or IPCC chapters. The path to convergence starts with the wider community admitting that they've been keeping a lid on the necessary discussions. <u>Suggest</u> If the Secretary is open to it a sentence might be added: "This report, like all expert reports before it, reflects the perspectives of the lead authors. I believe their arguments, and the evidence they bring to support them, have not been adequately presented in past assessments, to the detriment of the scientific and policymaking processes. This report is one step in restoring balance."
	viii	2	Any increase in greening from additional CO2 will likely be more than offset by longer growing seasons with higher temperatures (i.e., more days over 100). This causes serious risk to the US midwestern "bread basket", which is why this has been considered a national security concern. The data supporting this trend has been published a few times now in Science by a fellow out of Stanford, among others. Sources: Lobell and Field. 2007, doi: 10.1088/1748-9326/2/1/014002; also Sloat et al. 2020, doi:10.1038/s41467-020-15076-4 has a thorough introduction with many citations. The effects, including compound effects, on Agriculture are addressed in Ch 9

	viii	3	My understanding is that the upper bound of emissions (i.e., very high) is business as usual, with no mitigation, and a high-end of growth. It's a worst, yet plausible, case scenario. Similarly, the lowest emissions (i.e., very low) scenario includes technologies that don't yet exist including significant CO2 removal. Both are there to understand plausible extremes. The more likely scenarios are the low to high scenarios. I'm sure researchers are open to revisiting how things are bounded and presented if there are reasonable objections. It seems that within the expert community people are quick to set RCP8.5 aside as a fringe scenario. The problem is it dominates the impacts literature and the media coverage thereof. So the critical discussion herein is needed.
	viii	4	This may be true. But data driven analyses may not capture anticipated feedbacks. They attempt to by design. Limited by data especially ocean heat content but they take it into account.
	viii	6	I am a big fan of data and meta-analysis. However, I'll note that I do not think forest management practices are overlooked. In fact, it is one of the main driving story lines (i.e., too much fuelwood exists, so we need to harvest more forest). There remains strong debate on the efficacy of fuelwood removal over large areas as an effective means of wildfire reduction. The key to this analysis is to look at whether the extent (not the numbers) of fires has grown and whether the burned areas are returning to forests or returning to brush or grassland. If it's the latter, then that is more likely due to regional changes in climate (temp and precipitation). Again the issue may be what experts discuss among themselves versus what's out there publicly.
	viii	8	I think we can point to sea-level rise in south florida, crop damage, and disease vectors fairly easily. I'm not aware of what costs are associated with these 3 items, but I suspect it's quite large. Dealt with in Ch 11 on economic costs and the SCC.
	viii	9	Yes, this is an important paragraph. Most scientists are not activists. Just because there is a science finding, scientists don't expect that to turn into policy. The public and the democratic system can determine the policy using an evidence-based risk/benefit analysis, just as noted here. Opening up this conversation (which should have been done decades ago) would be welcome and would better engage the public on this issue. DOE could in fact take a leading role here and help address a major national issue. A point of sincere agreement.
1	2		This is all generally correct. I would like to think this is common knowledge. Yes but bears repetition
2	4	1	Why use studies based on satellite sensors? I'm quite sure there are studies (again, out of Stanford) that use historic yield data (county-scale USDA data and global FAO data) with associated temperature and precipitation data. Those analyses do not agree with your findings here, I think. But, we can certainly pose these questions to our scientists that study and develop land models and develop a report based on all available data. I'll also note that for sometime data synthesis wasn't considered fundamental science and was therefore largely ignored. Enabling the researchers to conduct robust data analyses on this and other topics would be largely welcomed. See Ch 9 on Ag effects for the studies on yield data.
2	5	Figure 2.2	All data is interesting and useful for perspective and understanding. But isn't the main question whether we are driving up CO2 and temp at a rapid pace in the post-industrial era? This graph does not help answer that question. The purpose of the graph is geological context which helps inform some issues around plant evolution.

2	7	3	Stating that increased aridity in drylands will not lead to decreased productivity seems a bit questionable. We can point to precipitation gradients from high to low precipitation that supports forests to grasslands to shrublands, respectively. Less water in general will mean less productivity; this can be seen in different forest compositions as well. The authors cite Zhang et al. (2014), but Zhang's main point is that the direct CO2 effect may be causing greening in drylands that offsets the decreased precipitation. This may be more specific to dryland vegetation, and Zhang et al. specifically state that this finding is relevant to north-east Brazil, Namibia, western Sahel, Horn of Africa, and central Asia. Zhang 2024, not 2014. The point here is to explain benefits of higher CO2 in terms of crop water productivity. Zhang acknowledges increase in desertification (as we note) but points to a global pattern of greening in arid areas.
2	9	3	I do not disagree with this observation of a decline effect, and I have seen it in some of the early biomass energy analyses that appeared in prominent journals and were then corrected over a few years. While it is unfortunate that some try to grab headlines with unsupported assumptions, it does seem that other researchers tend to provide counter arguments and analyses fairly quickly, indicating that the system does in fact work fairly well. Yes, part of the problem is the later counter-evidence gets relatively little attention, hence this report.
3	19	last	Yes, CO2 uptake by land processes have uncertainty associated with them. It's worth noting that DOE researchers (many of whom are retired now) were world-leading and making progress in this area, but nearly all work on CO2 uptake and emissions stopped 10-15 years ago due to political pressure and political concerns. The Carbon Dioxide Information and Analysis Center at ORNL, now cancelled, was a main contributor to the Global Carbon Project. Now the US is woefully behind and ceding expertise on this to the Europeans (as cited in this report). We are also ceding expertise on carbon monitoring via satellites to other countries. There's nothing necessarily wrong with this if this is where the US wants to go, but it's important to recognize that we have lost significant capacity due to policy changes over many years. We specifically recommend the government increase its focus on basic climate monitoring and data dissemination. The CDIAC was very valuable and I for one lament its closure.
5	44	1	Some of the early work on this topic was done by researchers at Stanford. But there are plenty of other papers. Here's one that came up in a quick search: https://www.pnas.org/doi/10.1073/pnas.0906865106 We discuss this paper in Ch 9.
5	44	1	Contradicting a number of large meta-analyses on the topic of decreased yields with increased temperature is ok. That's what science is all about. But it's going to have to be done in a more robust way than a couple paragraphs here with one or two citations. This section concerns temperature trends in the corn belt; the discussion of yields is in Ch 9.
6	47	chapter summary	This is very important. I have not dug into the data on extreme storm data (both numbers and intensity). Getting researchers together that disagree on a topic, analyze the data, and publish findings together can be very productive. DOE could sponsor a workshop and bring together a broad range of experts and find answers to extreme weather trends. Good idea

6	47	chapter summary	I conducted some analyses on wildfire years ago. I saw the bias in the university textbooks and in the wildfire working groups, who essentially went by textbook teachings. It was rare that people went back to the original data. The last time I checked the actual data (a good 10 years ago), I found that...you're correct...the number of fires had not changed much. What does seem to be changing is that the extent of fires has grown, and this is mostly attributable to hotter and drier conditions. I do not believe there is more fuel load now than there was before the US was settled. Arguing that harvesting will decrease fire is nonsensical; you have no idea where the lightning is going to strike and subsidizing the thinning of all forest in the western fire zone would be cost prohibitive. I think we need to stop using wildfire management as a justification for harvesting. If we want to harvest more, than do it, and stop using fuel load arguments (which is more of a concept than proven reality) as a reason to do it. The biggest issue here is encroachment of housing communities into the Wild-Urban Interface (WUI) and how we want to handle that with policies. Fire is really only bad if it's burning someone's house down. Otherwise, it's a natural progression in forest dynamics. Sources: Campbell et al. 2012. doi:10.1890/110057.; Schoennagel and Nelson. 2011. doi:10.1890/090199. Excellent comments. It's a big topic we can only glance at but we are trying just to get some pertinent data into the discussion.
6	57	6.3.2	The NCA5 is cited here and elsewhere. However, the USGCRP website that hosts the NCA reports has been removed. Hence, there is no way to read and review the referenced findings. This DOE report is therefore arguing against something that no longer exists, and that may appear questionable. Noted. Out of our control.
7	74	2	Given the satellite observed ice sheet dynamics, I'm not sure that ice sheet retreat is that hypothetical. Our reference is to hypothetical instabilities, i.e. massive disintegration.
7	all		This is the first time I have seen all sea-level rise estimates discredited by an offset from land subsidence. This is certainly a global dynamic that we would want to capture and understand in Earth system models, and DOE can look into this further with analyses and experiments if necessary. Noted.
8	86	all	This and other chapters cite the IPCC AR6. The IPCC provides a global process to address the issues and uncertainties in this report. Perhaps this report can set a path for pivoting research and re-engaging in a useful manner. That's a big ask.
9	104	chapter summary	The last sentence in this summary is not necessarily accurate. The authors cite Ainsworth and Long (2020) with respect to increased CO2 effects on crops. But, Ainsworth and Long (2020) indicate that increased temp and decreased precipitation will have negative impacts on crops, while increased CO2 may offset some of those negative effects. It is the impact of CO2 on climate and the subsequent impact on crops that is the concern; not the direct effect of CO2 on crops. Suggest last sentence in summary be written: "U.S. agriculture appears to be robust to current and expected CO2-induced warming."

Chapter Number	Page Number	Approximate Paragraph Number	Comment or Suggested Edit
2	3	2.1.1, para. 2	Zheng not in reference list. Do you mean Zeng? Yes, thanks.
2	3	2.1.1, para. 3	"nearly double"? Why exaggerate? - it's a 76% increase. And they reported that future increase in GPP in extra-tropical northern hemisphere (e.g., U.S.) for [CO2] from 300 to 600 ppm of 42%, or 32% more than previous predictions (not 76%). Suggest replacing “nearly double” with “much larger than”
2	3	2.1.1, para.1	Zhu also explained that "other factors (OF) not considered in models, such as forest management, grazing, changes in cultivation practices and varieties, irrigation and disturbances such as storms and insect attacks, can be a cause of mismatch between observed and simulated LAI trends.... OF contributes the most to the observed LAI trend over 25.0% (increase) and 5.3% (decrease) of the vegetated area" We don't claim CO2 is the only factor.
2	3	2.1.1, para.2	This report is meant to focus on the U.S., so it would be more appropriate to discuss greening trends in the U.S. Fig. 2.1 shows that the trend in LAI across much of the U.S., with the exception of the Southeast, is less than the global average. Negative OF effects are mainly found in northern high latitudes (e.g., Alaska). Growing season warmth is the dominant factor in cold regions (10.1038/s41558-018-0258-y). Significant browning also is occurring in parts of Alaska (10.1175/EI-D-20-0025.1) But the effect is still positive. In Ch 9 we discuss US-specific evidence concerning CO2 and crop yields.
2	3	2.1.1, para.2	Greening of the Arctic can have important adverse consequences. Direct observations support that warming and increased vegetation cover in the Boreal-Arctic region showed a "robust increasing trend of CH4 emissions (+8.9%) with strong inter-annual variability. The majority of emission increases occurred in early summer (June and July) and were mainly driven by warming (52.3%) and ecosystem productivity (40.7%)." Yuan et al 2024 (10.1038/s41558-024-01933-3). We don't claim it's good or bad, only that it's been observed.
2	3	2.1.1, para.3	Wang et al 2020 (10.1126/science.abb7772) report a decline over recent decades in CO2 effects on global photosynthesis, possibly due to increasing nutrient interactions or interactions with effects on LAI. It's a controversial finding that attracted skeptical comments in Science regarding the validity of the satellite data and the statistical methods used https://www.science.org/doi/10.1126/science.abg2947 https://www.science.org/doi/10.1126/science.abg4420 https://www.science.org/doi/10.1126/science.abg5673 While the authors in reply defend the satellite data they acknowledge they may not have dealt adequately with confounding non-CO2 factors. So it seems premature to invoke this result.

2	4	2.1.2	Much of this information in this section is appropriately covered in chapter 9 on agriculture. Chapter 2 purports to have a wider focus (global and environment responses), so it should not dwell on responses of individual crop plants (crops account for only 15% of global GPP). There has been plenty written on ecosystem response to eCO₂, but evidence such as Fig. 2.3 is not relevant. All analyses of direct eCO₂ effects reveal an overriding interaction with other environmental factors (nitrogen and temperature), and global models show that eCO₂ only partially compensates for the negative effects of climate change on ecosystem carbon response. We struggled with how to divide material up in Ch 2 and Ch 9. The solution we came up with was that here we are addressing direct CO₂ effects, namely CO₂ fertilization; later we discuss Ag effects in more detail. Not everyone paid attention in high school biology. Figure 2.3 serves as an illustration of a point that non-specialists are often surprised to learn, namely that CO₂ is plant food.
2	4	2.1.1, last para.	Zhang, 2025 (10.1016/j.ecolind.2025.113762) reported that although vegetation cover was increasing, resilience against external disturbances (drought, heatwaves, wildfires) has simultaneously declined. They use the lag-1 autocorrelation coefficient as the measure of resilience based on Critical Slowing Down theory. The results are suggestive but very noisy and require a lot of assumptions to equate to a loss of ecosystem resilience. Since the authors also show that vegetation cover is increasing at the same time the results don't appear strong enough to merit any change in our discussion.
2	7	2.1.3, para. 2	Cheng did NOT report "increased plant growth"; they reported increased GPP. The distinction is fundamentally important, has been recognized for decades, and is completely ignored in this chapter. Cheng et al. did refer to an increase in Net Primary Production as well, but you are correct they focused on Gross Primary Production. <u>Suggest</u> sentence be rephrased "Similarly, Cheng <i>et al.</i> (2017) noted that increased Gross Primary Production from 1982 to 2011 due to rising..." and GPP be added to the Glossary. More generally since GPP and NPP are closely correlated the use of "plant growth" is suitable.
2	6-7	2.1.3	This material is repeated in chapter 9 where it belongs. Here, it would be more appropriate to focus on how eCO₂ interacts with drought on ecosystem response (e.g., 10.3390/atmos12020212) We tried to avoid repetition but there is some. If the other reviewers flag it as well we will try to trim some more. We discuss drought in Ch 8: since we don't see global and US trends the issue of declining CO₂ fertilization during droughts isn't a key issue at this point.
3	19	3.2.2, last para.	Regarding the uncertainty in the land sink, a primary reason for this uncertainty is that the primary response of photosynthesis to CO₂ does not predict C sequestration because of strong interactions between CO₂ and climate, nutrients, stand dynamics, and other factors. That is why the almost complete focus in this report on crop plants and plant responses in greenhouses does not inform us about "CO₂ uptake by land processes" We aren't making any strong claims about the land sink, we only report the results in the Global Carbon Project. Not sure if the reviewer is challenging them or not.
9	104	all	This chapter is silent on agricultural effects on atmosphere and climate. Sokal and Kachel 2025 (10.3390/en18092272) conclude: "The current study demonstrated that agricultural activities significantly contribute to the emissions of three main greenhouse gases: carbon dioxide, nitrous oxide, and methane." Emissions from the Ag sector are included in the IAM results discussed in Ch 11.

9	105	9.2, para. 2	The section title is "Field studies..." but the next three paragraphs are primarily about responses of potted plants in growth chambers or greenhouses (with exception of Blandino, which was a field study and showed a much smaller response than the pot studies). There is an important reason that the field data cited in Blandino and in SoyFACE show a smaller response than data from the potted plants under artificial conditions. These data are barely relevant to the topic you are trying to address. FACE plot studies are field studies, and we also discuss other field studies. However we also include some lab experiments. Suggest heading be changed to "Field and laboratory studies of CO2 enrichment."
9	105	9.2, para. 3, 4, 5	CO2Science.org website is a highly biased and unreliable website. They report on papers, or specific sentences in papers, that support their view and ignore conflicting reports or qualifying sentences. If there was another site that gathered that much data we'd cite it. We'd need some evidence of actual bias to disqualify the CO2Science.org archive given the extent of its coverage.
9	105	9.2, para. 3	This is a report for the US. Why are you citing soybean studies in China when there is a major soyFACE study in Illinois? Yield in SoyFACE increased in eCO2 but declined with increasing temperature (10.1093/jxb/erac503). eCO2 did not result in water savings as hypothesized but rather increased soil moisture depletion. (10.1098/rstb.2024.0230) The Chinese study is on point regarding CO2 enrichment. The first study referenced by the reviewer (10.1093/jxb/erac503) only subjected soybean to elevated temperature without varying CO2, so it isn't relevant to our discussion. The second reference is to a general literature survey which doesn't appear to say anything different from what our chapter says.
9	106	9.2, para. 2	Ainsworth et al, 2025 (10.1093/jxb/erac503) state: "Early season stimulation in biomass at elevated [CO2] more than offset lower stomatal conductance in crops, resulting in greater depletion of soil moisture, instead of water savings [30,31]. Wheat tiller survival and grain filling was also reduced by elevated [CO2] under dry conditions [32]. The CO2 fertilization effect was also significantly reduced by growth at elevated temperatures in FACE experiments, again suggesting that high atmospheric [CO2] may not offset the negative impacts of global warming [29]. Thus, it may be that, to date, elevated [CO2] and the resultant climate changes have had net positive effects on agroecosystem productivity, but as climate change intensifies, there will be a shift towards net negative effects as has been suggested for natural ecosystems [3]." Our summary statement on the Ainsworth review is accurate regarding the CO2 effect. They raise the question of compound effects from simultaneous changes in CO2 and temperature. That topic is taken up in the discussion of the NBER study and Section 9.3

9	107	1st para.	Another study that should be cited is Hultgren et al, 2025 (10.1038/s41586-025-09085-w). "For all crops except rice, we estimate that warming will likely reduce global yields by 2050 (probability of loss ranges from 0.701 (sorghum) to 0.946 (wheat)... " "We estimate that global production declines 5.5×10^{14} kcal annually per 1 °C global mean surface temperature (GMST) rise (120 kcal per person per day or 4.4% of recommended consumption per 1 °C; $P < 0.001$). We project that adaptation and income growth alleviate 23% of global losses in 2050 and 34% at the end of the century (6% and 12%, respectively; moderate-emissions scenario), but substantial residual losses remain for all staples except rice." Regions with moderate average temperatures tend to suffer the largest yield losses. "Adjusting for CO2 fertilization does not qualitatively alter the structure of our findings ... but it does reduce the central estimate for end-of-century yield losses by 5.0– 9.5 percentage points... and increases the likelihood of positive aggregate effects." The Hultgren study came out after our draft had been complete. The headline results which generated massive publicity were based on RCP8.5 with no CO2 fertilization. One of our other reviewers wondered why we focused so much on the deficiencies of RCP8.5 when everyone knows it's a marginal case – this study is a good illustration of why. Fig 3 in Hultgren
9	108	1st	Reference to Ziska paper greatly mischaracterizes it. Ziska clearly indicates an effect of eCO2 on nutritional quality, but he indicates there is uncertainty in some of the mechanisms behind that response, including the simple dilution hypothesis. He states up front: "However, it is the direct effect of rising [CO2] on plant chemistry and stoichiometry that represents a continuing threat to the nutritional integrity of both human and animal systems." Ziska doesn't dismiss CO2, but he points out that nutrient dilution has also been observed under historical conditions in which CO2 was likely not the driver. <u>Suggest</u> sentence be rephrased "as is the evidence that nutrient dilution observed to date is entirely attributable to higher CO₂"
9	108	9.4, para. 1	Evidence for nutritional decline under eCO2 is widespread: Toreti et al, 2020 10.1038/s43016-020-00195-4) "A meta-analysis of 228 pairs of experimental observations on barley, potato, rice and wheat reported reductions in protein concentrations ranging on average from –15.3% to –9.8% under eCO2, while the reduction was relatively small (–1.4%) in soybean." AND Ainsworth et al 2025: "The positive 'CO2 fertilization' effect on crop yield is complicated by a decrease in many nutrients in elevated [CO2]. An analysis of 130 varieties of plants found that elevated [CO2] decreased the concentration of 25 important minerals by 8% on average, and the carbohydrate to mineral ratio was increased in these plants." We don't dispute any of this; it corresponds with what we say.
9	109		URL for Taylor and Schlenker paper is incorrect. It should be https://www.nber.org/papers/w29320. "papers" not "paper. Was this report peer reviewed? I cannot find it in a peer-reviewed journal. Thanks for the correction. I don't think it has appeared in print anywhere other than the NBER series.

12	129	This chapter is highly distressing, but I suppose it encapsulates the whole thesis of the document. Apparently, there is no point in policies to reduce emissions (or make the necessary changes in energy policy to accomplish emission reductions) because it will make no difference to the atmospheric CO2 concentration or climate. So why bother? Would you have said this in 1970 (CO2= 326), 1990 (CO2 = 354 ppm), or 2010 (CO2=390)? Probably so. And in 30 years when CO2 is 500 ppm, will it be fair to look back and evaluate your apparent call for inaction in the statement here "And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate." But I suppose this attitude is justified if there is no adverse consequence and the only important effect of rising CO2 is to make little plants in greenhouse grow bigger (e.g., Fig. 2.3), and indirect effects on heat stress, drought, fires, sea level, etc. aren't worth discussing. Points taken but the reviewer is calling attention to actual problems finding mitigation strategies with positive net benefits.
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Ch	Page	para	Comment or Suggested Edit
1	2	full text	This chapter points out that the primary concern around human emissions of CO2 is that it changes the radiative balance of the atmosphere. The chapter also makes the points that CO2 has no toxicological effects on humans at current atmospheric levels, and that CO2 is necessary for photosynthesis, with the potential to stimulate plant growth at higher concentrations. These points are well-established scientific facts. Yes and experts know them but non-experts aren't necessarily aware of them.
2	3	3	It would be more reflective of the literature to say here that "Many studies over the past decade have confirmed a global greening pattern (increase in LAI) attributable to rising CO2 levels, changes in climate, changes in nitrogen deposition, land cover change, and other factors." <u>Suggest</u> adding "in part" to sentence.
2	3	3	While the Zhu et al. 2016 study did find that 70.1% (+/- 29.4%) of the integrated global change in LAI was attributable to changes in CO2, most of the observed change in LAI is concentrated in the tropical forest regions of South America, Africa, and Indonesia, as shown in this report's Figure 2.1, reproduced from Zhu et al. In terms of the fraction of global land area influenced most by the factors considered in Zhu et al. 2016, effects on LAI from changing climate is the dominant factor (positive effects for 28.4% of land area plus negative effects on 4.7%, for a total area with dominant climate influence of 33.1%), followed by other factors not represented explicitly in the study or in the models (positive effects on LAI from other factors over 25.0% of land area plus negative effects over 5.3%, for a total area with other factors as the dominant effect of 30.3%), and then CO2 effects (23.2% of land area dominated by positive effects and 0.1% with negative effects, for a total of 23.4%). Since the report is focused on the U.S. it would be helpful to indicate the global context for the numbers reported. <u>Suggest</u> adding to paragraph "Other contributors included land-use changes, warming and nitrogen. The fraction attributable to CO2 was largest in the tropics; other factors played more dominant roles in CONUS."
2	3	3	The dominant factors related to changes in LAI over the U.S. (including Alaska) are land cover change (+LCC), climate effects (+CLI), other factors (+OF and -OF), and then CO2 (+CO2). There are more extensive regions where +CO2 is the dominant factor for the boreal forest zone in Canada. Given that, and given the explicit focus of the report on the U.S., it would be useful to call out in this section that the global greening pattern has distinct geographic variation in driving factors, and that over the target geography of the U.S. it seems to be dominated by factors other than increasing CO2. See my powerpoint slide 1 for a zoom on the area of interest from the Zhu et al. 2016 paper. Addressed with new sentence
2	3	4	"Zheng et al. (2017) confirmed the pattern..." should be modified to say "Zhen et al. (2017) confirmed the pattern of observed greening..." As written, and in the context of the previous paragraph, the current text suggests that Zheng et al. 2017 confirmed the pattern of greening being related mainly to increased CO2, a factor which was not examined in their study. <u>Suggest</u> change: confirmed the pattern of greening, noting that over thirty years it had added 8 percent...
2	3	4	Without the addition of the appropriate context in the preceding paragraph (my notes 3, 4, and 5) the remainder of this paragraph could be misinterpreted to mean that the impacts of greening on air temperature are attributable back to a positive effect of CO2 on greening. Rewording should address this.

2	3	4	The sentence "Greening has been observed globally but Chen et al. (2019) noted that China and India were exploiting it through land management changes" is misleading. Chen et al. (2019) shows that China and India are <i>causing</i> the observed greening in large areas by intentionally increasing the land area occupied by forests (China) and increases in harvested area in croplands, mainly due to multi-cropping, heavy fertilizer use, and expanded irrigation (China and India). It would be more accurate to say "Greening has been observed globally, but Chen et al. (2019) represent a disproportionate fraction of the total greening trend, accomplished through intentional increases in forest area (China), and expansion of multi-cropping, fertilizer use, and irrigation in croplands (China and India)." Suggest sentence read: "Greening has been observed globally. Chen et al. (2019) show that in China and India much of it is driven by land management changes"
2	3	3 and 4	Given the changes suggested in these two paragraphs, it raises the question of whether the section title (CO2 and global greening) is itself misleading. That title wrongly suggests that all the content to follow is reflective of a direct influence of CO2 on the observed global greening trends, when the literature presents a much more <i>nuanced</i> interpretation. Suggest title changed to CO2 as a contributor to global greening
2	3	3 and 4	It would be worth noting in this section that the multiple remote sensing-based datasets for LAI changes have remarkable differences, especially when comparing the figure 2.1 reproduced from Zhu et al. 2016 with the MODIS-based data record from Chen et al. 2019 (their figure 1). That means it is difficult to place a lot of confidence in the attribution of changes in different regions to different factors. See my powerpoint slide 2 for a comparison of the four datasets used in Zhu et al. 2016 and Chen et al. 2019. Thank you for this information. It is an interesting point but gets into more specialized detail than is necessary for this report.
2	3	5	The authorship for the Haverd et al. 2020 citation is not correct in the References section for this chapter. The correct citation is: Haverd, V., B. Smith, J. G. Canadell, M. Cuntz, S. Mikaloff-Fletcher, G. Farquhar, W. Woodgate, P. R. Briggs and C. M. Trudinger 2020. Higher than expected CO2 fertilization inferred from leaf to global observations. Global Change Biology 26(4): 2390-2402 DOI: https://doi.org/10.1111/gcb.14950. Thank you for the correction
2	3	5	A more recent and more comprehensive study (Keenan et al. 2023) reexamined multiple data constraints and concluded that the model used in Haverd et al. 2020 (CABLE) is outside the likely range of CO2 fertilization effects, with higher CO2 fertilization than indicated by multiple independent constraints. At the very least this more recent paper should be cited in the report, with text indicating that the central estimate from the TRENDY models is more likely to be in the range of observational constraints than is the CABLE result. As it stands the report suggests that the latest science indicates that most models have underestimated the fertilization effect, and the literature doesn't currently support that conclusion. See: Keenan, T. F., X. Luo, B. D. Stocker, M. G. De Kauwe, B. E. Medlyn, I. C. Prentice, N. G. Smith, C. Terrer, H. Wang, Y. Zhang and S. Zhou 2023. A constraint on historic growth in global photosynthesis due to rising CO2. Nature Climate Change 13(12): 1376-1381 DOI: 10.1038/s41558-023-01867-2. Suggest adding sentence However Keenan et al (2023) estimated a lower fertilization rate more in line with models.

2	4	1	The attribution analysis in the Chen et al. 2024 paper is very sensitive to the choice of multiple regression vs. partial correlation (their figures 3 vs S7, respectively), and in both cases they seem to misattribute the significant increases in LAI in India and China to CO2 rather than to changes in landcover and cropping practices. This kind of regression-based attribution is less informative than the model-based inference used for example by Zhu et al. 2016. The description of sensor calibration issues in this paper is also very cursory. It would probably be better to refer to the review paper of Piao et al. 2020 to support the claim of continued greening. Piao, S., X. Wang, T. Park, C. Chen, X. Lian, Y. He, J. W. Bjerke, A. Chen, P. Ciais, H. Tømmervik, R. R. Nemani and R. B. Myneni 2020. Characteristics, drivers and feedbacks of global greening. Nature Reviews Earth & Environment 1(1): 14-27 DOI: 10.1038/s43017-019-0001-x. Thank you for the comment. Suggest we take out the details about the Chen et al. analysis and say simply “Piao et al. (2020) and Chen et al. (2024) report that the greening trend continues with no evidence of slowdown, and CO2 fertilization remains the dominant driver”
2	4	2	The section 2.1.2 (Photosynthesis and CO2 levels) lacks coherence. It seems to be a collection of uncontroversial points about the ability of increased CO2 concentration to stimulate plant growth and reduce water loss through stomates. Figure 2.2 seems intended to show that the current levels of CO2 are not high compared to levels experienced in Earth's deep geologic past. A balanced treatment of the topic might call out the rate of change in CO2 concentration from human-caused emissions, and how both that rate and the absolute levels diverge radically from rates of change and ranges of variability over the past hundreds, thousands, and hundreds of thousands of years. See my powerpoint slide 3 for an example set of figures that might be included. In response to another reviewer we have added the sentence “While the modern rate of change in CO2 is likely high compared to all prior intervals, the geological evidence is that plants and animals evolved under much higher CO2 levels than at present.”
2	7	4	The report suggests that the topics of CO2 fertilization and increased water use efficiency are not adequately treated in recent IPCC reports. In IPCC's AR6 WG I report there is an entire chapter devoted to an assessment of carbon cycle processes (Chapter 5, Global Carbon and Other Biogeochemical Cycles and Feedbacks). This is precisely where one would expect to find information about CO2 fertilization and water use efficiency. In the Executive Summary for the chapter is the following bolded headline: Increases in atmospheric CO2 lead to increases in land carbon storage through CO2 fertilization of photosynthesis and increased water use efficiency (high confidence). The associated Executive Summary text includes reference to two figures, three chapter sections, and a cross-chapter box all dealing directly with this topic. The Executive Summary text also references the important topic of nutrient dynamics and their interactions with fertilization and ecosystem-climate feedbacks, a critical nuance of the interaction of CO2 and vegetation productivity that is ignored in the report reviewed here. We acknowledge that the topic is addressed in the body of IPCC reports. But we draw attention to its omission from summary documents.

2	8	2	Section 2.2.2 (Coral reef changes) has a strong focus on past examples of early investigations that are later updated. There is also a note about the difficulty of publishing negative results, with a quote that this pattern "is true across all of science". Given the objective of this report, I suggest a shift in tone away from complaints about the kinds of papers that do and don't receive media attention, and instead highlight the latest synthesis of results about the likely future of coral reefs. A relatively recent synthesis paper (Cornwall et al. 2021) in a well-respected journal (PNAS) based on collated data from 233 locations worldwide projects that 37% of reefs will stop accreting and thus fail to keep up with sea level rise by 2050 under the low emissions RCP2.6 scenario, and no reefs would be able to accrete at a rate to stay ahead of sea level rise by 2100 under either RCP4.5 or RCP8.5. This analysis finds that most of the loss of net accretion rate is due to bleaching events, and a minority of the impacts are due to "direct physiological impacts of ocean warming and acidification on calcification or bioerosion". C.E. Cornwall, S. Comeau, N.A. Kornder, C.T. Perry, R. van Hooidek, T.M. DeCarlo, M.S. Pratchett, K.D. Anderson, N. Browne, R. Carpenter, G. Diaz-Pulido, J.P. D'Olivo, S.S. Doo, J. Figueiredo, S.A.V. Fortunato, E. Kennedy, C.A. Lantz, M.T. McCulloch, M. González-Rivero, [...] & R.J. Lowe, Global declines in coral reef calcium carbonate production under ocean acidification and warming, Proc. Natl. Acad. Sci. U.S.A. 118 (21) e2015265118, https://doi.org/10.1073/pnas.2015265118 (2021). This is a model projection study whereas for the very limited purpose of this section we are focusing on current and historical observations.
3	14	1	The study by Connolly et al. 2021 uses a linear regression approach to estimate the amount of variability in surface temperature trends that could be explained by total solar irradiance time series. Their approach is to first model the temperature trend with TSI as the dependent variable, and then compare the residuals from that fit to anthropogenic forcing factors. This is an obviously biased approach, and in fact a full paper was published the following year (in the same journal) laying out the erroneous methods and the faulty conclusions they produce (Richardson and Benestad 2022). Richardson, M. T. and R. E. Benestad 2022. Erroneous use of Statistics behind Claims of a Major Solar Role in Recent Warming. Research in Astronomy and Astrophysics 22(12): 125008 DOI: 10.1088/1674-4527/ac981c. While I agree with R&B that a partial regression is biased unless the regressors are orthogonal, Connolly et al. replied in 2023 at https://iopscience.iop.org/article/10.1088/1674-4527/acf18e in which they used updated AR6 data and reproduced their main result using multiple regression. However they also emphasized that it is only one of many possible results depending on choice of solar proxy and surface T record,
3	18	1	Section 3.2.2 (The carbon cycle relating emissions and concentrations). There is no new information or analysis presented in the chapter, and it relies heavily on Global Carbon Project information. Figure 3.2.3 is described as showing a seven-fold difference in the recent trend in land carbon sink estimates across land models, and this is given as a potential driver of uncertainty in future carbon cycle and climate change predictions. Variation among models is well known and is one of the reasons exercises like CMIP and GCP rely on multi-model ensembles when assessing the state of the science. The distribution of results looks fairly typical in this diagram, with a strong central value around 1.3 to 1.3. We're not claiming to have added new information, just reviewing what's out there.

12	129	3	The following sentence is misleading: "And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate." It is true that bringing global emissions immediately to zero would not reduce CO2 concentrations on short timescales. It is not true that this same scenario means no reduction in human influence on the climate. We must compare the zero emissions scenario to something, and the most meaningful comparison is the current trajectory of increasing emissions and the resulting super-linear increase in concentration. So by reducing emissions to zero we clearly avoid the expected increases in concentration and the expected increases in radiative forcing together with increased near surface air temperature and all the other expected consequences. So our change in action - going to zero emissions - does in fact have an immediate and growing human influence on the trajectory of the climate system. That is not an argument for reducing our emissions to zero tomorrow, it is just an argument for logic and clarity in how we talk about consequences of different actions. The sentence in the text is correct. It's also true to say that going to zero emissions would, over time, open up a widening gap between observed and counterfactual. But realistically we are only looking at marginal changes. The stock-flow mismatch is one reason IAMs have not recommended going to zero emissions.
12	129	5	Regarding the sentence "The practice of referring to unilateral U.S. reductions as "combatting climate change" or "taking action on climate" therefore reflects a profound misunderstanding of the scale of the issue." This makes the dubious assumption that when people refer to "combating climate change" or "taking action on climate" they are ignorant of the scale of the problem. Instead, it is probably more justifiable to assume that it is well-understood by most people who advocate for these local and national changes that the major emitters must act together to make a big difference in global emissions. It is at least worth considering, in the context of this report, that a path toward action at the necessary scale will require local and national action from a broad consortium, and that individual advocacy is a useful and necessary starting point for shifting the inertia of global policies. <u>Suggest</u> sentence be modified to read "The practice of referring to unilateral U.S. reductions as "combatting climate change" or "taking action on climate" on the assumption we can stop climate change therefore reflects a profound misunderstanding"

Chapter Number	Page Number	Approximate Paragraph Number	Comment or Suggested Edit
Foreword	vii	4	The stated charge to the team was to summarize the current state of climate science, but in the Preface the team states that it chose to focus on topics that are downplayed in or absent from current assessment reports. To accurately describe the contents of the report, the Foreword should also state that the report is a summary of the things that the author team thinks have been downplayed in major climate assessment reports.
Foreword	vii	8	The statement about climate change not being the greatest threat facing humanity is a value judgement. Since the Secretary criticizes others for blurring the line between scientific conclusions and policy recommendations in the second, fourth, and sixth paragraphs of this Foreword, it is hypocritical to offer a value judgement without clearly labeling it as such and noting that such conclusions must necessarily involve one's beliefs in addition to scientific information.
Exec Summ	viii	2	It is misleading (cherry picking) to only mention "global greening" (i.e., the influence of elevated CO2 on plant growth) here without also noting the impacts of elevated temperatures and changing precipitation patterns on ecosystem health and agricultural productivity. (This comment is also true of the underlying content on pages 3-7)
Exec Summ	viii	2	It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems and fisheries. (This comment is also true of the underlying content on pages 8-9)
Exec Summ	viii	3	It is inaccurate to say that "scenarios of CO2 emissions have tended to overestimate observed levels". As the authors themselves note on page 15, it is impossible to reliably predict societal behavior regarding energy production and other sources of emissions, so the climate science community has never provided or suggested that there is a single predictive scenario against which future emissions could be judged. Rather, there has always been a range of projected emissions scenarios, and emissions have always tracked within the envelope of those scenarios. The authors make a reasonable point in the full text about the large number of climate studies that have used RCP 8.5, whereas actual emissions have recently been closer to RCP 4.5. This would be a more appropriate finding to include here in the executive summary.
Exec Summ	viii	4	Stating that climate models "offer little guidance on how the climate responds to elevated CO2" is at best an unjustified (and at worst a biased) judgement given that the authors chose to focus only on the shortcoming and deficiencies of these models, and do not account for the progress made in improving the ability of these models to reproduce many key aspects of observed climate change. The same is true for all of Chapter 5.

Exec Summ	viii	5	Stating that climate models "generally run hot" is an inaccurate and misleading summary statement. A large number of papers and scientific assessments have validated the ability of climate models to accurately simulate many major aspects of global climate. Like all models, climate models are imperfect, and some models have recently shown a tendency to produce higher climate sensitivities--the IPCC AR6 acknowledged this "hot model problem" and there has been considerable discussion in the scientific literature about it and its implications for impacts studies. But this is a relatively recent phenomenon, and there could be other reasons for the recent mismatch (i.e., under-estimates of the reduction in aerosol cooling due to air pollution controls). A balanced scientific assessment would also note, for example, that climate model projections from the 1970s and 80s have accurately predicting the observed trend in global temperature over the past few decades.
Exec Summ	viii	6	It is misleading and inaccurate to say that most extreme weather events do not show long terms trends. It is true that some kinds of extreme events, like tornadoes, have not shown appreciable or detectable changes, and that changes in wildfire must account for changes in land management. But a "summary of the current state ofthe science" should acknowledge that there is clear evidence that heat waves are becoming more frequent and more extreme, extreme precipitation and nuisance flooding are becoming more common, etc. (This comment is also true of the underlying content in Part II)
Exec Summ	viii	6	It is misleading to state that the aggregate sea-level rise trend in U.S. tide gauges is not accelerating, because as noted in the same sentence, there are significant regional differences in SLR (primarily due to differences in land subsidence), so only looking at domestic gague data is insufficient to determine if sea-level rise--an inherently global process--is accelerating, with regional factors superimposed on that global trend. There is clear evidence that global sea level rise is accelerating. Moreover, while land subsidence has offset sea level rise in some U.S. regions, the opposite is true in others, and in those reasons the combined effects of sea level rise and subsidence are posing considerable risks to people and infrastructure in those regions...but this important context is omitted. (The same is true of the sea level rise analysis on pages 75-78.)
Exec Summ	viii	9	Most of the sentences in this paragraph are not factual in nature. For example, the call for uninterrupted observations of the global climate system is a research recommendaiton that is outside the remit of this report and is not supported by text within the document. The same sentence also implies that current emissions scenarios are not "realistic", which is not a defensible statement given that historical emissions have tracked within the envelope of previous emission projections (see comment above and Figure 3.2.2), and argues that climate models should address biases and uncertainties, which is something that every climate modeling team already spends an enourmous amount of time doing. If retained, the non-scientific portions of this paragraph should be moved to the Preface, and the misleading statements should be corrected.

Preface	ix	1	The focus on "whether carbon dioxide emissions endanger the U.S. public" is slightly different from the stated focus in the Foreword on "the Nation's climate". This distinction is important because climate change and its impacts outside of U.S. borders can endanger the U.S. public both directly (e.g., global processes affecting sea level rise in the United States, or the impacts of climate change on overseas military installations) and indirectly (i.e., impacts of climate change on international agricultural production and trade dynamics).
2	3	1	The two summary statements provide an extremely narrow and misleading view of "direct impacts of CO2 on the environment" (the chapter title). The most obvious direct impact of CO2, in the context of climate change, is its role in global radiative forcing, which is covered in the next chapter but not mentioned here. The chapter should at a minimum be retitled, but better yet combined with the following chapter which discusses other aspects of increasing CO2.
2	3	2	It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems, fisheries, and other processes.
2	5	1	It is misleading to show (only) a graph of CO2 levels over hundreds of millions of years. These timescales are generally not relevant to processes and issues surrounding anthropogenic CO2 increases. For example the authors in multiple places make statements about CO2 levels during the last glacial maximum, but those fluctuations are undetectable on a graph with such a long timescale.
2	8	1	acidification is not a misnomer...the word literally means to make something more acidic, which is what is happening. The authors may choose to argue that the term is misleading since the oceans are slightly basic, but that is not the same thing as a misnomer.
2	8	1	It is misleading and largely irrelevant to discuss ocean pH levels tens of thousands or millions of years ago, because that timescale is not relevant to the impacts associated with anthropogenic ocean acidification on ocean life. It is well documented that recent changes in ocean pH are happening ~100 times faster than natural fluctuations prior to human CO2 emissions, and marine species must adapt to changes in conditions on timescales of a few of their lifetimes, which is clearly not millions of years.
2	9	4	Similar to previous comment--changes in marine life over hundreds of millions of year has little relevance to the survival of marine species on decadal timescales due to anthropogenic ocean acidification. Are the authors trying to suggest that U.S. society would be well served by going back to conditions during the Jurassic?
3	13	2	The IPCC probably discounted the results reported in Connolly (2021) because that study included methodological errors that were documented in several subsequently publications, which the authors do not acknowledge. A serious assessment of TSI would not cherry-pick a single study, especially one that has been shown to include serious errors.

3	14	4	It is unclear what the authors mean by "other natural sources of energy imbalance". If the authors are aware of a plausible additional source of energy imbalance they should state what it is rather than making vague statements without providing any evidence that such sources might exist.
3	14	5	This is one of several places where the authors discuss the CO2 levels at which C3 plants begin dying in the context of the last glacial maximum. This is misleading, because there is no evidence that CO2 levels would have continued falling below the levels of the last glacial maximum, and irrelevant to the stated focus of this report, because they rebounded to 280 ppm many centuries before human activities began producing large amounts of CO2.
3	15	1	The oceans and land surface absorb more like 60% of CO2 emissions. The 50% figure is repeated multiple times in the ensuing pages and should be corrected.
3	20	2	The final sentence on this page is misleading and confusing as written. Most studies of the land carbon sink suggest that the rate at which it is increasing is declining, and several studies suggest that the ocean sink is declining. The authors should also explain the relevance of their statements here, because it isn't clear.
4	26	6	The inclusion of a paragraph with high-level summary statements about climate policy here is confusing and inappropriate. This content belongs in chapter 11.
4	29	1	The point about observed global temperature trends being consistent with both high-ECS high-aerosol and low-ECS low-aerosol worlds is an important one. It would be good to acknowledge that uncertainty in ECS is not just due to uncertainties in climate models, but also the lack of accurate measurements of pre-industrial aerosols and thus anthropogenic changes in aerosol forcing. And this uncertainty cuts both ways--if we live in a high-ECS world that has been "masked" by strong aerosol cooling, reducing air pollution could result in rapid warming (and this may be linked to the "hot model" problem as well).
4	29	2	The point about ECS values derived from past climate states (especially cooler ones) possibly not being totally representative of the current climate is another good point, one that would be good to acknowledge in their earlier and later discussions about uncertainty and the rationales for emissions reductions (e.g., on page 26 and in Chapter 11).
4	30	1	The relatively shallow treatment on TCR relative to ECR here is puzzling, since the authors acknowledge that it is better constrained, and it is also a more relevant value for projected warming over the next several decades. The first sentence here also describes it as an observational constraint, but it is not, it is a metric that can be produced from either data or models (or both), and climate models are routinely used to run TCR experiments.
5	32	1	A more accurate title of this chapter would be "deficiencies in climate models" because the authors focus almost exclusively on processes and features that models have struggled to reproduce, rather than a balanced assessment that also indicates what these models do well.

5	34	1	Scaffeta (2023) has been widely criticized in the scientific literature for its methods and conclusions. These results should not be presented without acknowledging these concerns, or better yet, the authors should attempt to survey the literature on this topic rather than presenting results from a single controversial paper.
5	34	2	Spencer (2024) is not a peer reviewed journal paper and is not really appropriate to include here when there are many papers on this topic that have been peer reviewed.
5	35	1	The statement that the signal for anthropogenic greenhouse warming emerges first and most strongly is not supported and is inconsistent with my understanding of climate dynamics. The following sentence is also dubious (and probably backwards) since models run with observed surface temperatures tend to produce much better mid-tropospheric temperature simulations.
5	36	1	In most places the authors correctly describe the discrepancy between models and observations as a mismatch, which is appropriate because observations of mid-tropospheric temperatures are also subject to uncertainty (as indicated in the error bars in Figure 5.4). This is one of the reasons for the IPCC confidence assessment noted in the following paragraphs. However, here and in a few other places in this section the writing implies that differences can be solely attributed to model deficiencies.
5	37	1	This section should be combined with the previous one as it is really just elaborating on the same discrepancy between climate models and observational estimates of tropospheric temperatures.
5	39	1	There has indeed been considerable controversy about this particular metric. It is curious that the authors choose to cite two older papers here (2008 and 2009) rather than the rich recent literature, especially since they went to the trouble of updating on of their graphics with 2024 data. Recommend including a more balanced assessment of this discrepancy, it's potential causes, and recent efforts to address it, as well as noting that climate models are able to accurately capture many other aspects of climate change.
5	39	1	This entire section is very misleading as it cherry-picks a specific result and takes it out of important context. The reason why stratospheric cooling has slowed (and, at least in one study, even warmed) in the past two decades is due to the recovery of the ozone layer. This is clearly stated in the Philipona et al article cited by the authors and in the IPCC report. Additionally, satellite-based estimates of stratospheric temperature (which is data the authors highlight in the previous section) do not show the same trends. This section should be removed or amended to note that stratospheric temperatures are influenced by multiple factors and that a comprehensive analysis of stratospheric temperature trends is fully consistent with those projected under climate warming scenarios.
5	41	1	Many observational studies have shown that snow cover is decreasing, and have explained why it is more meaningful and useful to look at spring trends in snow cover, as well as why observations of snow cover can be uncertain.

5	42	4	The authors provide a relatively accurate survey of results regarding hurricane numbers and landfall frequency, which have indeed not shown any trends. But their analysis of hurricane intensity, which has been shown in many studies to increase, is lacking...the chart showing just estimated windspeeds of the top ten landfalling storms is really weak given the analytical talents of the author team. They also do not provide any discussion of the physical basis for why hurricane numbers may not be changing while the intensity of the strongest hurricanes is expected to increase, nor analyze any data in the context of those conclusions.
6	47	5	Long term persistence is not a recognized property or phenomenon associated with rainfall data. The use of such a statistical technique, especially one that is not widely recognized or used in the hydroclimate community, demands additional justification.
6	53	4	The authors have cherry picked results throughout this section. For example, they have selected only a few quotes from IPCC and NCA describing extreme heat. The absolute single daily maximum temperature for a given year, for example, is a poor statistic for assessing statistical changes in extreme heat (it would be like comparing the tallest person in each country to try to calculate change in average height). A complete and comprehensive review of the underlying assessments and the data it cites clearly shows that extreme heat has been increasing in North America.
6	56	1	The "climate less prone to extremes" is a misleading statement. If minimum temperatures are increasing faster than maximum temperatures (which is an expectation of climate change based on basic physical principals), then the difference between warm and cold extremes on many timescales is expected to decrease. There are reasonable points to be made regarding observational deficiencies, regional variations in extreme events, and the potential benefits of reductions in extreme cold, rather than coming up with misleading statistics.
6	58	3	The NCA5 heading is not a controversial statement, it simply says that things are changing, which they are by the author's own admissions and graphs. It does not suggest pervasive positive trends, as the authors suggest it does.
6	61	3	The statistical techniques used in the 2019 paper are highly non-standard for evaluating precipitation statistics, and the 2024 results have not been peer reviewed. The results reported in the NCA and IPCC and the underlying studies have clearly demonstrated that extreme precipitation is increasing.
6	61	7	The relevance of the paragraph on 19th century and paleoclimatic rainfall events is unclear. If anything, the fact that such extremes have occurred in the past argues for more aggressive adaptation measures to ensure that damages won't be as high if they happen again (even notwithstanding potential changes in risk due to climate change). Note, however, that additional context is provided in the box that follows two pages later.
6	62	1	The choice of looking at (only) 5-day precipitation totals is questionable. Most rainfall events, including the most extreme and damaging precipitation events, are typically on a daily timescale.

6	68	3	Perhaps this is more germane to the sea level rise section, but nuisance (high tide) flooding due to sea level rise has been observed across much of the united states.
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Ch	page	Para	Comment or Suggested Edit
2	5	Fig 2.2	The graph is not relevant to the discussion. It should only, at most, cover the time period since the last glacial maximum, which occurred ~20 kyr BCE, and common practice is to concentrate on the last 1000 years.
3	11,12	Sec 3.1.1	There is no quantification of the effects of TSI and volcanic aerosols that would lead to modifications of the radiative forcing shown in the figures In ch 6 we discuss ranges of TSI forcing that even the IPCC acknowledges.
3	21,22	Sec 3.3	Many of the arguments and references are dated. Further, the challenge posed is to prove a negative, i.e. that the record used by AR6 is not biased by urban heat island effects. On the contrary, while verbally stating uncertainty, the authors cannot make a claim that the AR6 statement is false. Even if one were to accept the Soon, et al value of 0.89 deg C/century, the focus on the land surface warming completely neglects the contribution of the oceans to global surface temperature change, which must be considered in any discussion of surface temperature change. The underlying studies frame statistical tests appropriately to test for the presence or absence of an effect. Yes the literature is dated and the topic needs renewed attention. The question is bias in the land record, but no one is arguing all surface warming is due to urbanization.
4	30	Sec 4.4	The statement "TCR is more generally related to peak warming and better constrained by historical warming, than ECS." requires further context. While true that the "peak warming" rate achieves a maximum around 70 years, temperature increases continue for several centuries and approaches the ECS value asymptotically. Further, the Lewis (2023) arguments were placed in context by Sherwood and Forest (2024), that identified multiple recent ECS studies that showed, collectively, that the PDF in their original Sherwood, et al paper could not be narrowed. Additionally, the reference to Sherwood et al (2020) is incorrect. It omits many authors and the authors that are listed are not in the correct order. Reference to peak warming deleted.
5	37, 38	Sec 5.4	The analysis presented of the IPCC AR5 figure, Fig 5.6 in the current document, is outdated and should be removed. The issue IS addressed in the AR6, but not graphically, in the text reproduced by the authors. If the section is retained, it should be moved ahead of Section 5.3 to present the material in the correct order chronologically. The analysis in Fig. 5.6 matches the updated data in Fig 5.7, and it is relevant to show that the information was included in the AR5 but only in a figure in the Supplement. The order of presentation in the chapter is appropriate.
6	57	para 1	The conclusion "The rise in Tmin has been strongly related to the growing presence of manufactured surfaces around the weather stations over the last 100+ years (the so-called urban heat island effect; Section 3.3 and Spencer et al. 2025)." is only found in an author's self-citation of Spencer, et al, (2025) that does not appear in the references at the end of Chapter 6. Further, the trend of greater increases in Tmin relative to Tmax is documented and explained in Easterling, et al (1997). https://doi.org/10.1126/science.277.5324.364 ; Thorne, et al (2016) https://doi.org/10.1002/2015JD024584 . The trend cannot be attributed to UHI effects. We will add citations to the literature to substantiate the point.
8	85	para 5	"... datasets with high TSI variability can explain more than 70 percent of the temperature variability since preindustrial times." Variability on what time scales? 11-year cycles? How would this impact the well documented surface temperature increase of > 1 deg C global temperature change since 1900? There is a whole spectrum of variability in TSI beyond the 11-year cycle. These are discussed in the papers we reference.

8	85,86,87	"Natural variability of large-scale ocean circulations"	The discussion neglects the influence of vertical mixing on surface temperature. The global ocean has warmed, as documented by increases in global ocean heat content, e.g. Murphy, et al (2009) doi:10.1029/2009JD012105 We do not understand the comment.
8	88,89	Optimal fingerprinting discussion	This section is hardly a balanced and objective review. The report authors are known opponents of optimal fingerprint approaches and have been a loud, but very small minority voice. It is interesting that even they conclude "...these analyses do not falsify results of the IPCC optimal fingerprinting method..." The point is that falsification would require redoing all the underlying studies. The findings however show that the method is flawed and the justification for relying on it is invalid.
8	90,91,92	Section 8.4	This discussion is incomplete and fails to take into account the extensive literature on cloud and surface albedo feedbacks.. There is an extensive discussion about the post 2015 period and recent record annual global surface temperatures, implying, but not stating, that recent changes are the result of natural variability, or decreases in atmospheric aerosol concentrations. Comparing the radiative forcing from these changes with long-term GHG forcing, particularly CO2 is misleading to the average reader. If the reduction in albedo can be tied to atmospheric cloud and aerosol changes, as the authors state, they cannot ignore the likelihood that the changes are the result of anthropogenic factors, i.e. sulfate aerosol reduction through cleaner technology and the well-documented positive low-cloud feedback. The discussion is incomplete because the underlying science is incomplete, as we emphasize. We are surveying a complex area of ongoing research without taking a strong position ourselves.
Full document			In the limited time allowed, this reviewer concentrated on sections related to the physical climate and climate change. Frankly, the document was discouraging. Secretary Wright wants a " ... a more thoughtful and science-based conversation about climate change and energy." I find that this report distorts the science in much the same way as the media coverage about which he complains. Most notable are the omissions or under-reported significant climate changes, such as sea-ice decline, changes in the global water cycle and increases in heat-stress due to increases in absolute humidity (from water-vapor feedback). Further, the examples used by the report authors are narrow and appear to be selected to emphasize uncertainty, while the more rigorously evaluated science that contradicts their limited discussion is ignored, perhaps because it does not fit their narrative. This is unfortunate, because I believe it detracts from the much needed discussion about the future, including energy policies, technologies and trade-offs. I encourage DOE to start the discussion by accepting the well-reviewed and broadly accepted scientific conclusions of the IPCC Working Group 1, with respect to the observations and analyses of climate change in the 20th and 21st centuries. Skepticism regarding predictions/projections of future climate based on posited scenarios is justified. As a member of the physical climate research community, I believe there are better uses for the models (and the computer resources they consume) than scenario projection simulations, to inform the discussion that is urgently needed about the future. Comments noted.

Chapter Number	pg	para	Comment or Suggested Edit
Foreword	vii	4	The stated charge to the team was to summarize the current state of climate science, but in the Preface the team states that it chose to focus on topics that are downplayed in or absent from current assessment reports. To accurately describe the contents of the report, the Foreword should also state that the report is a summary of the things that the author team thinks have been downplayed in major climate assessment reports. Noted, the Preface has been modified. Our charge was not to summarize the whole of climate science.
Foreword	vii	8	The statement about climate change not being the greatest threat facing humanity is a value judgement. Since the Secretary criticizes others for blurring the line between scientific conclusions and policy recommendations in the second, fourth, and sixth paragraphs of this Foreword, it is hypocritical to offer a value judgement without clearly labeling it as such and noting that such conclusions must necessarily involve one's beliefs in addition to scientific information. We did not write the Secretary's foreword.
Exec Summ	viii	2	It is misleading (cherry picking) to only mention "global greening" (i.e., the influence of elevated CO2 on plant growth) here without also noting the impacts of elevated temperatures and changing precipitation patterns on ecosystem health and agricultural productivity. (This comment is also true of the underlying content on pages 3-7) This issue has been addressed with wording changes to acknowledge the other contributors.
Exec Summ	viii	2	It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems and fisheries. (This comment is also true of the underlying content on pages 8-9) The statement has been removed.
Exec Summ	viii	3	It is inaccurate to say that "scenarios of CO2 emissions have tended to overestimate observed levels". As the authors themselves note on page 15, it is impossible to reliably predict societal behavior regarding energy production and other sources of emissions, so the climate science community has never provided or suggested that there is a single predictive scenario against which future emissions could be judged. Rather, there has always been a range of projected emissions scenarios, and emissions have always tracked within the envelope of those scenarios. The authors make a reasonable point in the full text about the large number of climate studies that have used RCP 8.5, whereas actual emissions have recently been closer to RCP 4.5. This would be a more appropriate finding to include here in the executive summary. The point being made here is that observations have tracked the low end of the envelopes, a problem going back decades. See Figure 3.2.1
Exec Summ	viii	4	Stating that climate models "offer little guidance on how the climate responds to elevated CO2" is at best an unjustified (and at worst a biased) judgement given that the authors chose to focus only on the shortcoming and deficiencies of these models, and do not account for the progress made in improving the ability of these models to reproduce many key aspects of observed climate change. The same is true for all of Chapter 5. It is informative for readers to see key ways in which models fail to match observations especially those most relevant for policy making. The continuing wideness of the range of responses is an important limitation to their fitness for purpose.

Exec Summ	viii	5	Stating that climate models "generally run hot" is an inaccurate and misleading summary statement. A large number of papers and scientific assessments have validated the ability of climate models to accurately simulate many major aspects of global climate. Like all models, climate models are imperfect, and some models have recently shown a tendency to produce higher climate sensitivities--the IPCC AR6 acknowledged this "hot model problem" and there has been considerable discussion in the scientific literature about it and its implications for impacts studies. But this is a relatively recent phenomenon, and there could be other reasons for the recent mismatch (i.e., under-estimates of the reduction in aerosol cooling due to air pollution controls). A balanced scientific assessment would also note, for example, that climate model projections from the 1970s and 80s have accurately predicting the observed trend in global temperature over the past few decades. Our statements are substantiated by the Figures in Ch 5 (especially Figs 5.2 - 5.4). As we discuss the problem of the tropospheric mismatch goes back decades.
Exec Summ	viii	6	It is misleading and inaccurate to say that most extreme weather events do not show long terms trends. It is true that some kinds of extreme events, like tornadoes, have not shown appreciable or detectable changes, and that changes in wildfire must account for changes in land management. But a "summary of the current state ofthe science" should acknowledge that there is clear evidence that heat waves are becoming more frequent and more extreme, extreme precipitation and nuisance flooding are becoming more common, etc. (This comment is also true of the underlying content in Part II) The chapter presents a great deal of data that substantiates our summary statement. We also provide clear indications on heatwave trends including where they are increasing in frequency. Our assessments match those in the IPCC and NCA documents.
Exec Summ	viii	6	It is misleading to state that the aggregate sea-level rise trend in U.S. tide gauges is not accelerating, because as noted in the same sentence, there are significant regional differences in SLR (primarily due to differences in land subsidence), so only looking at domestic gague data is insufficient to determine if sea-level rise--an inherently global process--is accelerating, with regional factors superimposed on that global trend. There is clear evidence that global sea level rise is accelerating. Moreover, while land subsidence has offset sea level rise in some U.S. regions, the opposite is true in others, and in those reasons the combined effects of sea level rise and subsidence are posing considerable risks to people and infrastructure in those regions...but this important context is omitted. (The same is true of the sea level rise analysis on pages 75-78.) The reviewer needs to provide evidence for the claim of acceleration. SLR is a regionally-heterogeneous phenomenon and we discuss the differences by location. We present tide-gauge data for many locations so readers can see the situation for themselves.
Exec Summ	viii	9	Most of the sentences in this paragraph are not factual in nature. For example, the call for uninterrupted observations of the global climate system is a research recommendaiton that is outside the remit of this report and is not supported by text within the document. The same sentence also implies that current emissions scenarios are not "realistic", which is not a defensible statement given that historical emissions have tracked within the envelope of previous emission projections (see comment above and Figure 3.2.2), and argues that climate models should address biases and uncertainties, which is something that every climate modeling team already spends an enourmous amount of time doing. If retained, the non-scientific portions of this paragraph should be moved to the Preface, and the misleading statements should be corrected. The paragraph has been moved to the end of Chapter 12. See above regarding emission scenarios.

Preface	ix	1	The focus on "whether carbon dioxide emissions endanger the U.S. public" is slightly different from the stated focus in the Foreward on "the Nation's climate". This distinction is important because climate change and its impacts outside of U.S. borders can endanger the U.S. public both directly (e.g., global processes affecting sea level rise in the United States, or the impacts of climate change on overseas military installations) and indirectly (i.e., impacts of climate change on international agricultural production and trade dynamics). The reference to endangerment has been removed.
2	3	1	The two summary statements provide an extremely narrow and misleading view of "direct impacts of CO2 on the environment" (the chapter title). The most obvious direct impact of CO2, in the context of climate change, is its role in global radiative forcing, which is covered in the next chapter but not mentioned here. The chapter should at a minimum be retitled, but better yet combined with the following chapter which discusses other aspects of increasing CO2. The effect of CO2 on the climate takes up the bulk of the report.
2	3	2	It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems, fisheries, and other processes. The evidence we cite shows that pH levels are in the range of natural variability. Whether the rate of change is much more difficult to establish because of the limitations of paleo records. Also the spatial heterogeneity is not subject to comprehensive measurement, which precludes straightforward assessment.
2	5	1	It is misleading to show (only) a graph of CO2 levels over hundreds of millions of years. These timescales are generally not relevant to processes and issues surrounding anthropogenic CO2 increases. For example the authors in multiple places make statements about CO2 levels during the last glacial maximum, but those fluctuations are undetectable on a graph with such a long timescale. The figure has been removed.
2	8	1	acidification is not a misnomer...the word literally means to make something more acidic, which is what is happening. The authors may choose to argue that the term is misleading since the oceans are slightly basic, but that is not the same thing as a misnomer. We consider it a misnomer for the reasons stated. The oceans are not becoming acidic.
2	8	1	It is misleading and largely irrelevant to discuss ocean pH levels tens of thousands or millions of years ago, because that timescale is not relevant to the impacts associated with anthropogenic ocean acidification on ocean life. It is well documented that recent changes in ocean pH are happening ~100 times faster than natural fluctuations prior to human CO2 emissions, and marine species must adapt to changes in conditions on timescales of a few of their lifetimes, which is clearly not millions of years. The referee needs to provide specific sources for these statements. Also, it is a relevant point to make if current marine life evolved under conditions of much lower pH.
2	9	4	Similar to previous comment--changes in marine life over hundreds of millions of year has little relevance to the survival of marine species on decadal timescales due to anthropogenic ocean acidification. Are the authors trying to suggest that U.S. society would be well served by going back to conditions during the Jurassic? See earlier response.

3	13	2	The IPCC probably discounted the results reported in Connolly (2021) because that study included methodological errors that were documented in several subsequently publications, which the authors do not acknowledge. A serious assessment of TSI would not cherry-pick a single study, especially one that has been shown to include serious errors. The reviewer is probably referring to a comment by Richardson and Benestad, but Connolly et al. replied effectively to their critique.
3	14	4	It is unclear what the authors mean by "other natural sources of energy imbalance". If the authors are aware of a plausible additional source of energy imbalance they should state what it is rather than making vague statements without providing any evidence that such sources might exist. Surely the reviewer acknowledges that there are unknowns in the climate system
3	14	5	This is one of several places where the authors discuss the CO2 levels at which C3 plants begin dying in the context of the last glacial maximum. This is misleading, because there is no evidence that CO2 levels would have continued falling below the levels of the last glacial maximum, and irrelevant to the stated focus of this report, because they rebounded to 280 ppm many centuries before human activities began producing large amounts of CO2. The reviewer needs to provide evidence for the assertion that CO2 levels would not have continued falling.
3	15	1	The oceans and land surface absorb more like 60% of CO2 emissions. The 50% figure is repeated multiple times in the ensuing pages and should be corrected. We are unfamiliar with the 60% number; the sources with which we are familiar generally report numbers closer to 50%. We will check but again the reviewer has not cited any sources for his or her statement.
3	20	2	The final sentence on this page is misleading and confusing as written. Most studies of the land carbon sink suggest that the rate at which it is increasing is declining, and several studies suggest that the ocean sink is declining. The authors should also explain the relevance of their statements here, because it isn't clear. Our statement is consistent with the sources we cite. Unfortunately the reviewer did not provide references.
4	26	6	The inclusion of a paragraph with high-level summary statements about climate policy here is confusing and inappropriate. This content belongs in chapter 11. We only make a brief introductory statement and otherwise defer the discussion to Ch 11.
4	29	1	The point about observed global temperature trends being consistent with both high-ECS high-aerosol and low-ECS low-aerosol worlds is an important one. It would be good to acknowledge that uncertainty in ECS is not just due to uncertainties in climate models, but also the lack of accurate measurements of pre-industrial aerosols and thus anthropogenic changes in aerosol forcing. And this uncertainty cuts both ways--if we live in a high-ECS world that has been "masked" by strong aerosol cooling, reducing air pollution could result in rapid warming (and this may be linked to the "hot model" problem as well). Agreed
4	29	2	The point about ECS values derived from past climate states (especially cooler ones) possibly not being totally representative of the current climate is another good point, one that would be good to acknowledge in their earlier and later discussions about uncertainty and the rationales for emissions reductions (e.g., on page 26 and in Chapter 11). Agreed.

4	30	1	The relatively shallow treatment on TCR relative to ECR here is puzzling, since the authors acknowledge that it is better constrained, and it is also a more relevant value for projected warming over the next several decades. The first sentence here also describes it as an observational constraint, but it is not, it is a metric that can be produced from either data or models (or both), and climate models are routinely used to run TCR experiments. ECS is more widely-used than TCR which is why we focus more attention on it.
5	32	1	A more accurate title of this chapter would be "deficiencies in climate models" because the authors focus almost exclusively on processes and features that models have struggled to reproduce, rather than a balanced assessment that also indicates what these models do well. We changed the title to take this into account.
5	34	1	Scaffeta (2023) has been widely criticized in the scientific literature for its methods and conclusions. These results should not be presented without acknowledging these concerns, or better yet, the authors should attempt to survey the literature on this topic rather than presenting results from a single controversial paper. The reviewer is referring to an exchange regarding a different paper. We are unaware of any published critiques of the Scafetta paper we cite.
5	34	2	Spencer (2024) is not a peer reviewed journal paper and is not really appropriate to include here when there are many papers on this topic that have been peer reviewed. The reviewer should have provided references. We are unaware of any peer reviewed papers that present the comparison we show. We provide traceable accounts for the underlying data, all of which is from official sources.
5	35	1	The statement that the signal for anthropogenic greenhouse warming emerges first and most strongly is not supported and is inconsistent with my understanding of climate dynamics. The following sentence is also dubious (and probably backwards) since models run with observed surface temperatures tend to produce much better mid-tropospheric temperature simulations. The statement about early and strong emergence of the CO2 signal in the tropical troposphere is in the IPCC TAR and subsequent reports. Even models constrained with observed sea surface temperatures produce excess amplification aloft.
5	36	1	In most places the authors correctly describe the discrepancy between models and observations as a mismatch, which is appropriate because observations of mid-tropospheric temperatures are also subject to uncertainty (as indicated in the error bars in Figure 5.4). This is one of the reasons for the IPCC confidence assessment noted in the following paragraphs. However, here and in a few other places in this section the writing implies that differences can be solely attributed to model deficiencies. We don't take a position on the ultimate cause however we do note that the biases are pervasive across models and multiple observational data sets.
5	37	1	This section should be combined with the previous one as it is really just elaborating on the same discrepancy between climate models and observational estimates of tropospheric temperatures. One section discusses the discrepancy of trends and the other discusses the discrepancy of amplification rates, which is why the sections are separate.

5	39	1	There has indeed been considerable controversy about this particular metric. It is curious that the authors choose to cite two older papers here (2008 and 2009) rather than the rich recent literature, especially since they went to the trouble of updating on of their graphics with 2024 data. Recommend including a more balanced assessment of this discrepancy, it's potential causes, and recent efforts to address it, as well as noting that climate models are able to accurately capture many other aspects of climate change. Again, it is unfortunate that the reviewer did not provide any citations to the rich recent literature. We cited the key papers we are aware of.
5	39	1	This entire section is very misleading as it cherry-picks a specific result and takes it out of important context. The reason why stratospheric cooling has slowed (and, at least in one study, even warmed) in the past two decades is due to the recovery of the ozone layer. This is clearly stated in the Philipona et al article cited by the authors and in the IPCC report. Additionally, satellite-based estimates of stratospheric temperature (which is data the authors highlight in the previous section) do not show the same trends. This section should be removed or amended to note that stratospheric temperatures are influenced by multiple factors and that a comprehensive analysis of stratospheric temprature trends is fully consistent with those projected under climate warming scenarios. We will add a sentence discussing the ozone recovery issue and make reference to the recent Santer et al. study.
5	41	1	Many observational studies have shown that snow cover is decreasing, and have explained why it is more meaningful and useful to look at spring trends in snow cover, as well as why observations of snow cover can be uncertain. The issue here is model projections versus observations. Again, the reviewer provides no citations.
5	42	4	The authors provide a relatively accurate survey of results regarding hurricane numbers and landfall frequency, which have indeed not shown any trends. But their analysis of hurricane intensity, which has been shown in many studies to increase, is lacking...the chart showing just estimated windspeeds of the top ten landfalling storms is really weak given the analytical talents of the author team. They also do not provide any discussion of the physical basis for why hurricane numbers may not be changing while the intensity of the strongest hurricanes is expected to increase, nor analyze any data in the context of those conclusions. The challenge for global intensity metrics is that the satellite record prior to 1990 is inadequate, which is why we focus on the Atlantic hurricane data. Also there is no theory for hurricane number; that is a topic associated with substantial uncertainty.
6	47	5	Long term persistence is not a recognized property or phenomenon associated with rainfall data. The use of such a statistical technique, especially one that is not widely recognized or used in the hydroclimate community, demands additional justification. We have rewritten the text to remove specific reference to LTP.

6	53	4	The authors have cherry picked results throughout this section. For example, they have selected only a few quotes from IPCC and NCA describing extreme heat. The absolute single daily maximum temperature for a given year, for example, is a poor statistic for assessing statistical changes in extreme heat (it would be like comparing the tallest person in each country to try to calculate change in average height). A complete and comprehensive review of the underlying assessments and the data it cites clearly shows that extreme heat has been increasing in North America. The reviewer fails to identify any data or conclusion from the IPCC or NCA that differs from our assessment, and fails to cite any sources to justify this comment.
6	56	1	The "climate less prone to extremes" is a misleading statement. If minimum temperatures are increasing faster than maximum temperatures (which is an expectation of climate change based on basic physical principals), then the difference between warm and cold extremes on many timescales is expected to decrease. There are reasonable points to be made regarding observational deficiencies, regional variations in extreme events, and the potential benefits of reductions in extreme cold, rather than coming up with misleading statistics. But we show that extreme heat has also declined since the 1930s – Figures 6.3.1 and 6.3.3 refute the reviewer's statement.
6	58	3	The NCA5 heading is not a controversial statement, it simply says that things are changing, which they are by the author's own admissions and graphs. It does not suggest pervasive positive trends, as the authors suggest it does. We're not sure what sentence the reviewer is referring to.
6	61	3	The statistical techniques used in the 2019 paper are highly non-standard for evaluating precipitation statistics, and the 2024 results have not been peer reviewed. The results reported in the NCA and IPCC and the underlying studies have clearly demonstrated that extreme precipitation is increasing. The 2019 paper uses ordinary least squares to compute the trend, and a standard variance estimator from the econometrics literature to assess significance. As we point out, we also find evidence of increasing precipitation averages and extremes but only when selecting certain start dates.
6	61	7	The relevance of the paragraph on 19th century and paleoclimatic rainfall events is unclear. If anything, the fact that such extremes have occurred in the past argues for more aggressive adaptation measures to ensure that damages won't be as high if they happen again (even notwithstanding potential changes in risk due to climate change). Note, however, that additional context is provided in the box that follows two pages later. We agree that discovery of extreme events in the 19th century records indicates that disaster planning may need to encompass a wider range of risks.
6	62	1	The choice of looking at (only) 5-day precipitation totals is questionable. Most rainfall events, including the most extreme and damaging precipitation events, are typically on a daily timescale. Again, the reviewer provides no citations or evidence. Our results are robust to different day intervals, and we refer to 1- and 2-day results as well.
6	68	3	Perhaps this is more germane to the sea level rise section, but nuisance (high tide) flooding due to sea level rise has been observed across much of the United States. This is a topic we did not address.

From: Judith Curry <curry.judith@gmail.com>
Sent: Thursday, July 31, 2025 5:24 PM
To: Fisher, Travis
Cc: Roy Spencer; Park, Charles; Ross McKittrick; John Christy; Steven Koonin; Loucks, Joshua; Cohen, Seth
Subject: Re: [EXTERNAL] DOE reviews

Thanks. I think Ross' version in msword is easier to work with, including the color coded comments.

On Thu, Jul 31, 2025 at 2:18 PM Fisher, Travis <travis.fisher@hq.doe.gov> wrote:

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Cc: Ross McKittrick <ross.mckittrick@gmail.com>; John Christy <climateman60@gmail.com>; Steven Koonin <steven.koonin@googlemail.com>; Josh Loucks <loucksj14@gmail.com>; Cohen, Seth <seth.cohen@hq.doe.gov>; Fisher, Travis <travis.fisher@hq.doe.gov>
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Professor of Economics

Department of Economics and Finance

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Our deadline for submissions is Monday 11 August 2025 - 0900 GMT.

Many thanks in advance.

Best wishes, Leo

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Leo Hickman

Editor, Carbon Brief

Phone: + 44 (0) 7731 403979

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Judith Curry, President
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<http://www.cfanclimate.net>

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Attachments: DOE Report Review Master Ordered.xlsx

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Leo Hickman

Editor, Carbon Brief

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Social: Twitter; BlueSky; LinkedIn

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7	4	29	2
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2	4	30	Sec 4.4
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8	4	30	1
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3	4.2	27	2
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3	4.2	27	3
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3	4.3		
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1	5	32	1
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8	5	32	1
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7	5	32	3
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1	5	33	Figure
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7	5	34	1
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8	5	35	1
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8	5	36	1
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7	5	36	1
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1	5	37	3
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8	5	37	1
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7	5	38	3
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1	5	39	Figure 5.7
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8	5	39	1
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8	5	41	1
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8	5	42	4
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7	5	42	2
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6	5	44	1
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6	5	44	1
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7	5	44	3
2	5	37, 38	Sec 5.4
3	5.1	33	
3	5.2	34	figure
3	5.3	36	figure 5.4
3	5.4	37	4
3	5.4	38	
3	5.7	42	
1	6	47	1
1	6	47	1
1	6	47	3
6	6	47	chapter summary

6	6	47	chapter summary
8	6	47	5
7	6	47	2
7	6	47	3
7	6	47	5
1	6	50	Figure
1	6	52	4
1	6	53	Table
1	6	53	5
8	6	53	4
1	6	54	1

8	6	56	1
2	6	57	para 1
6	6	57	6.3.2
7	6	57	2
1	6	58	Figure
1	6	58	4
1	6	58	4
8	6	58	3
7	6	58	3
1	6	59	3
7	6	59	4

7	6	60	1,2
1	6	61	3 to 6

8	6	61	3
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8	6	61	7
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7	6	61	4
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8	6	62	1
7	6	62	2

7	6	63	box
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7	6	64	1
1	6	67	2

1	6	68	7
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8	6	68	3
1	6	69	1

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1	6	69	4
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7	6	69	2
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7	6	70	2
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7	6	71	3
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3	6		6.4, 6.6, 6.7
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3	6.2		
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3	6.3	60	
3	6.3	56-57	
6	7	74	2
1	7	75	1
7	7	80	1
6	7	all	
3	7		
1	8	83	3
1	8	84	6
1	8	84	6
2	8	85	para 5
6	8	86	all
7	8	88	3

1	8	90	3
1	8	92	2
7	8	92	4
1	8	93	4
7	8	93	3
3	8	94	table 8.1
2	8	85,86,87	"Natural variability of large-scale ocean circulations"
2	8	88,89	Optimal fingerprinting discussion
2	8	90,91,92	Section 8.4
3	8.3	84	3
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3	8.4	91	2 and 3
3	8.6	95	2
3	8.6		
1	9	104	1
	9	104	all
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6	9	104	chapter summary
	9	105	9.2, para. 2
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	9	105	9.2, para. 3, 4, 5
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	9	105	9.2, para. 3
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7	9	105	2,3,4,5
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	9	106	9.2, para. 2
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7	9	106	1
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	9	107	1st para.
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	9	108	9.4, para. 1
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1	10	112	1
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1	10	113	7
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3	10.2	111	
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7	11	117	3

7	11	118	3
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1	11	116-120	Section 11.1
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1	11	Chapter	Chapter
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Comment or Suggested Edit

- I would like to thank the authors for the opportunity to provide comment on this report. Providing decision-makers with information about the impacts of carbon dioxide emissions on the U.S. climate is critical as they face consequential decisions about the future of energy, agricultural, and environmental policy. Assessments of the science such as IPCC reports and the NCA benefit from undergoing robust review including expert review, public review, and government review with review comments and responses made publicly available. Similarly, important government reports and regulations undergo inter-agency review and are published in the Federal Register for a full notice and comment process and publish a public response to comment. While these processes are far from perfect, they offer the opportunity for improvement and help lend authority to the final products, and I highly encourage you to undertake a similar robust and open peer review process for this report to enhance the report's credibility in the eyes of decision-makers and the public.

In the limited time allowed, this reviewer concentrated on sections related to the physical climate and climate change. Frankly, the document was discouraging. Secretary Wright wants a " ... a more thoughtful and science-based conversation about climate change and energy." I find that this report distorts the science in much the same way as the media coverage about which he complains. Most notable are the omissions or under-reported significant climate changes, such as sea-ice decline, changes in the global water cycle and increases in heat-stress due to increases in absolute humidity (from water-vapor feedback). Further, the examples used by the report authors are narrow and appear to be selected to emphasize uncertainty, while the more rigorously evaluated science that contradicts their limited discussion is ignored, perhaps because it does not fit their narrative. This is unfortunate, because I believe it detracts from the much needed discussion about the future, including energy policies, technologies and trade-offs. I encourage DOE to start the discussion by accepting the well-reviewed and broadly accepted scientific conclusions of the IPCC Working Group 1, with respect to the observations and analyses of climate change in the 20th and 21st centuries. Skepticism regarding predictions/projections of future climate based on posited scenarios is justified. As a member of the physical climate research community, I believe there are better uses for the models (and the computer resources they consume) than scenario projection simulations, to inform the discussion that is urgently needed about the future.

The report indicates numerous examples of uncertainties in climate science. It would be extremely helpful if these uncertainties were made more explicit, listed in a concluding section, and prioritized in some way - what are the top 10 priority research areas? If the opening remarks by Secretary Wright and the title pointed to uncertainties and the need for more research, I believe this report will be better received. As I read the report and left review comments below, **I bolded items where I gather the authors imply that research is needed.** Consider including these kinds of statements throughout and adding a summary.

In general, criticism and re-analysis of past research is always welcome. This report summarizes some substantial concerns from a small group of researchers. The report should be reframed to reflect this and I provide some suggestions in a later comment. I suspect that simply publishing this report will not offset the hundreds of reports and publications on CO2 and Climate that have come before it. But, new analyses and communication within and outside the research community could make a positive difference, should the findings in this report be substantiated. The DOE Office of Science BER could be provided an opportunity to address the research uncertainties in this document in a thorough and robust manner.

As someone who used to read the DOE reports on CO2 as a graduate student in the 1990s and then conducted numerous analyses of carbon on many topic areas which were later confirmed by numerous other analyses, it seems somewhat cavalier for DOE to issue one brief conclusive report on the "impacts of carbon dioxide emissions". I suggest the following option: Change the title to "Topics of Uncertainty on the Impacts of Carbon Dioxide Emissions on the U.S. Climate" or "**An Assessment of CO2 Impacts on Climate to Guide Future Research**", and then use this report to drive research/analyses for each report chapter which would conclude in separate topical reports that could be finished within a year or two. In doing so, the DOE would positively contribute to addressing some of these standing issues and hopefully enable the nation to move forward in a more productive manner.

The stated charge to the team was to summarize the current state of climate science, but in the Preface the team states that it chose to focus on topics that are downplayed in or absent from current assessment reports. To accurately describe the contents of the report, the Foreword should also state that the report is a summary of the things that the author team thinks have been downplayed in major climate assessment reports.

The statement about climate change not being the greatest threat facing humanity is a value judgement. Since the Secretary criticizes others for blurring the line between scientific conclusions and policy recommendations in the second, fourth, and sixth paragraphs of this Foreword, it is hypocritical to offer a value judgement without clearly labeling it as such and noting that such conclusions must necessarily involve one's beliefs in addition to scientific information.

I appreciate the perspective. It could be useful to add or edit the Secretary's Forward to indicate that "**the report has been purposefully commissioned to researchers with alternative perspectives in an effort to address these perspectives and provide some closure for the American public, the US Economy, and US energy policy.**" I suggest this, because it will be very obvious that a handful of skeptics were chosen out of literally hundreds of extremely active and well-respected scientist. Addressing that upfront will immediately reduce criticism, and hopefully generate a positive environment to address these issues. Everyone would like to see convergence of findings on these issues.

It is misleading (cherry picking) to only mention "global greening" (i.e., the influence of elevated CO2 on plant growth) here without also noting the impacts of elevated temperatures and changing precipitation patterns on ecosystem health and agricultural productivity. (This comment is also true of the underlying content on pages 3-7)

It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems and fisheries. (This comment is also true of the underlying content on pages 8-9)

It is inaccurate to say that "scenarios of CO2 emissions have tended to overestimate observed levels". As the authors themselves note on page 15, it is impossible to reliably predict societal behavior regarding energy production and other sources of emissions, so the climate science community has never provided or suggested that there is a single predictive scenario against which future emissions could be judged. Rather, there has always been a range of projected emissions scenarios, and emissions have always tracked within the envelope of those scenarios. The authors make a reasonable point in the full text about the large number of climate studies that have used RCP 8.5, whereas actual emissions have recently been closer to RCP 4.5. This would be a more appropriate finding to include here in the executive summary.

Stating that climate models "offer little guidance on how the climate responds to elevated CO2" is at best an unjustified (and at worst a biased) judgement given that the authors chose to focus only on the shortcoming and deficiencies of these models, and do not account for the progress made in improving the ability of these models to reproduce many key aspects of observed climate change. The same is true for all of Chapter 5.

Stating that climate models "generally run hot" is an inaccurate and misleading summary statement. A large number of papers and scientific assessments have validated the ability of climate models to accurately simulate many major aspects of global climate. Like all models, climate models are imperfect, and some models have recently shown a tendency to produce higher climate sensitivities--the IPCC AR6 acknowledged this "hot model problem" and there has been considerable discussion in the scientific literature about it and its implications for impacts studies. But this is a relatively recent phenomenon, and there could be other reasons for the recent mismatch (i.e., under-estimates of the reduction in aerosol cooling due to air pollution controls). A balanced scientific assessment would also note, for example, that climate model projections from the 1970s and 80s have accurately predicting the observed trend in global temperature over the past few decades.

It is misleading and inaccurate to say that most extreme weather events do not show long terms trends. It is true that some kinds of extreme events, like tornadoes, have not shown appreciable or detectable changes, and that changes in wildfire must account for changes in land management. But a "summary of the current state of the science" should acknowledge that there is clear evidence that heat waves are becoming more frequent and more extreme, extreme precipitation and nuisance flooding are becoming more common, etc. (This comment is also true of the underlying content in Part II)

It is misleading to state that the aggregate sea-level rise trend in U.S. tide gauges is not accelerating, because as noted in the same sentence, there are significant regional differences in SLR (primarily due to differences in land subsidence), so only looking at domestic gauge data is insufficient to determine if sea-level rise--an inherently global process--is accelerating, with regional factors superimposed on that global trend. There is clear evidence that global sea level rise is accelerating. Moreover, while land subsidence has offset sea level rise in some U.S. regions, the opposite is true in others, and in those regions the combined effects of sea level rise and subsidence are posing considerable risks to people and infrastructure in those regions...but this important context is omitted. (The same is true of the sea level rise analysis on pages 75-78.)

Most of the sentences in this paragraph are not factual in nature. For example, the call for uninterrupted observations of the global climate system is a research recommendation that is outside the remit of this report and is not supported by text within the document. The same sentence also implies that current emissions scenarios are not "realistic", which is not a defensible statement given that historical emissions have tracked within the envelope of previous emission projections (see comment above and Figure 3.2.2), and argues that climate models should address biases and uncertainties, which is something that every climate modeling team already spends an enormous amount of time doing. If retained, the non-scientific portions of this paragraph should be moved to the Preface, and the misleading statements should be corrected.

- There is a disconnect between the stated intent of the report by the authors in the preface, "whether carbon dioxide emissions endanger the U.S. public," and this executive summary, as well as the organization of the report. Would suggest aligning by either reframing the focus in the preface to better match the organization of the report, or better aligning the report organization with the stated focus.

This would be more correct: "Some scenarios of future CO2 emissions overestimate observed levels"

This would be more correct: Some detailed climate models run "hot" in their simulation of the climate of the past few decades, while many have underestimated the amount of surface warming. **More research is needed to select the most skillful and reliable models.**

Need reference for: "Claims of increased frequency or intensity of hurricanes, tornadoes, floods, and droughts are not supported by historical data." **More research is needed to identify how frequency and intensity of weather events are affected by environmental conditions.**

The greening effect can't be due to increase in CO2 alone. The fertilization effect needs Nitrogen and phosphorous. There is observational[1] evidence that nitrogen available to plants is decreasing with increasing CO2 and thus acting to limit fertilization effect. Secondly, the greening of some portions of the planet are likely due to changes in precipitation patterns associated with changing climatic conditions and not entirely attributable to fertilization effect. We will also need to consider that the temperature effect on photosynthesis will also be a limiting mechanism to any continued greening due to fertilization in the future [2]. I recommend acknowledging that the greening is not attributable to CO2 alone and continued greening in the future with increasing CO2 is uncertain.

Any increase in greening from additional CO2 will likely be more than offset by longer growing seasons with higher temperatures (i.e., more days over 100). This causes serious risk to the US midwestern "bread basket", which is why this has been considered a national security concern. The data supporting this trend has been published a few times now in Science by a fellow out of Stanford, among others. Sources: Lobell and Field. 2007, doi: 10.1088/1748-9326/2/1/014002; also Sloat et al. 2020, doi:10.1038/s41467-020-15076-4 has a thorough introduction with many citations.

My understanding is that the upper bound of emissions (i.e., very high) is business as usual, with no mitigation, and a high-end of growth. It's a worst, yet plausible, case scenario. Similarly, the lowest emissions (i.e., very low) scenario includes technologies that don't yet exist including significant CO2 removal. Both are there to understand plausible extremes. The more likely scenarios are the low to high scenarios. I'm sure researchers are open to revisiting how things are bounded and presented if there are reasonable objections.

This may be true. But data driven analyses may not capture anticipated feedbacks.

I am a big fan of data and meta-analysis. However, I'll note that I do not think forest management practices are overlooked. In fact, it is one of the main driving story lines (i.e., too much fuelwood exists, so we need to harvest more forest). There remains strong debate on the efficacy of fuelwood removal over large areas as an effective means of wildfire reduction. The key to this analysis is to look at whether the extent (not the numbers) of fires has grown and whether the burned areas are returning to forests or returning to brush or grassland. If it's the latter, then that is more likely due to regional changes in climate (temp and precipitation).

I think we can point to sea-level rise in south florida, crop damage, and disease vectors fairly easily. I'm not aware of what costs are associated with these 3 items, but I suspect it's quite large.

Yes, this is an important paragraph. Most scientists are not activists. Just because there is a science finding, scientists don't expect that to turn into policy. The public and the democratic system can determine the policy using an evidence-based risk/benefit analysis, just as noted here. Opening up this conversation (which should have been done decades ago) would be welcome and would better engage the public on this issue. DOE could in fact take a leading role here and help address a major national issue.

I am glad we acknowledge that CO2 causes warming, though I am not sure why we are not considering other energy sector related emissions that also cause warming (CFCs/HFCs, methane, aerosol effects). It is not clear what is meant by "CO2 emissions have tended to overestimate observed trends". This is not correct, the cumulative emissions track the RCP8.5 scenario the closest [3,4]. While there was a decrease in emissions during the Covid-19 period the emissions are now back on track following RCP8.5. This statement should clarify what is meant by the statement in the text.

This paragraph seems to be talking about equilibrium climate sensitivity. The most recent model inter-comparison gives a wider range of climate sensitivities in the range of 1.8 to 5.7 and is wider than estimates of climate sensitivities that have been estimated from paleoclimatic and more recent historical datasets, in the range could be in the range of 2.3 to 4.5 K[5]. The higher sensitivity in the most recent model assessments are an area of active investigation by modelers, the feasibility of a higher range needs to be confirmed with additional observational and process scale modeling [6]. The range for climate sensitivities, 1.8-2.7, should be corrected to the most recent findings, 2.3-4.5. We should also recognize that the (a)earth is a complex system of systems (b)we can't do an experiment to find out what is correct or reduced the uncertainty. As we get better at extracting temperature records and CO2 concentrations from paleo data, there will be better reconstructions and possibly narrower range along with improvements in modeling that resolve many physical, biological and chemical processes as we get to higher and cloud resolving spatial resolutions.

This is again not true for the majority of the models in the AR6. Figure 7.19 in the IPCC AR6 report shows that majority of the models exhibit a range within the observational range. The models running hot in the most recent decades are the ones with climate sensitivities greater than 5K, which are 3 out of a total of 40 and it should be noted that about the same number of models also are running cold' compared to observed[7]

There is very little dispute that these are challenging issues for climate science. Many of the issues identified here related to compound effects (subsidence and sea-level rise; wildfire and forest management) that requires further scientific investigation. Identifying further research avenues/focus areas will be helpful to firm up some of the challenges faced in using the climate projections as discussed in the paragraph 9.

The focus on uncertainty is relevant and should be emphasized in future research. However, as a reasonable policy pathways, making decisions in the face of these uncertainties is critical. Most of the climate uncertainties that we have confidence at this time can be considered Level 2 and Level 3 uncertainties, approaches such as scenario analysis (and others) are suggested and followed for making hazard and risk estimates for future conditions. For deep uncertainty hazards (for example tornadoes etc.) that we don't have enough data or capability to model, developing methods for assessing the uncertainty and risk should be a focus of future research.

- “While the report is intended to be accessible to non-experts, we have omitted some introductory or explanatory material that can easily be accessed elsewhere. Nor have we attempted to survey entire literatures related to the topics covered.”
 - While this approach is understandable given the time constraints this report was produced under, given the level of visibility this report will have, it potentially opens up the report to criticism of being misleading by omission – focusing on areas where the authors disagree with the broader scientific literature and omitting areas large areas that are known about climate where there is less disagreement.
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- “We have focused as much as possible on literature published since 2020 and referenced previous IPCC and NCA assessment reports. We have also used data through 2024 where possible.”
 - This is a good approach for this report; however, much of the literature cited is from pre-2020, and many of the references to IPCC and NCA reports are to older reports (e.g. NCA 4 and IPCC AR 4&5) instead of NCA 5 and IPCC reports from the 6th assessment cycle. In these sections that heavily cite this older literature, it is not clear if the newer literature does not address these points or if the issues raised in the older literature are resolved or significantly changed in the newer literature.
-
- The IPCC’s mandate is to assess the scientific literature comprehensively, including a range of views, and report disagreements. This report has a tendency to selectively quote the IPCC focusing on disagreements and excluding areas where scientists agree. This approach risks giving a misleading picture of the state of the science through omission. A possible way to address this is to have a section summarizing areas of agreement by pointing to all statements of fact and high confidence statements from IPCC AR6 before digging into the more controversial areas with disagreement. This could be a short discussion about areas of agreement up front before explaining the focus of this report on these areas of disagreement, with the IPCC statements of fact and high confidence statements included in an appendix.
 - The report also includes only a very small subset of the literature since 2020. The authors should describe the approach to how they selected the literature included, and if possible, point to any systematic ways excluded literature could lead to different conclusions.
 - It is also notable that there a fair amount of new analysis in this report done by the authors that has not yet been peer reviewed. It would be good to flag these spots with a note about why these are needed while other related peer reviewed articles are excluded.
- The focus on "whether carbon dioxide emissions endanger the U.S. public" is slightly different from the stated focus in the Foreword on "the Nation's climate". This distinction is important because climate change and its impacts outside of U.S. borders can endanger the U.S. public both directly (e.g., global processes affecting sea level rise in the United States, or the impacts of climate change on overseas military installations) and indirectly (i.e., impacts of climate change on international agricultural production and trade dynamics).
- If the goal of this report is to discuss links between CO2 and climate, this is an odd way to begin the report with a focus on differences between CO2 and criteria air pollutants.

- “It is an issue of concern because of its potential effects on the global climate, a complex issue that occupies much of this report.” Suggest deleting the word potential as the existence of the effect is not disputed.
- “But the primary concern about CO2 is its role as a greenhouse gas (GHG) that alters the earth’s energy balance.” Would add “warming the planet” to the end of this sentence as the qualitative effect is not debated and the concern is not about the energy balance itself but about the warming effects of the imbalance.

This chapter points out that the primary concern around human emissions of CO2 is that it changes the radiative balance of the atmosphere. The chapter also makes the points that CO2 has no toxicological effects on humans at current atmospheric levels, and that CO2 is necessary for photosynthesis, with the potential to stimulate plant growth at higher concentrations. These points are well-established scientific facts.

This is all generally correct. I would like to think this is common knowledge.

The reason CO2 was identified as a pollutant is the health consequences of increased temperature, flooding and other climate impacts and not because of any direct affect on health due to exposure to atmospheric CO2[8].

- “The recent decline in pH is within the range of natural variability on millennial time scales. Most ocean life evolved when the oceans were mildly acidic. Decreasing pH might adversely affect corals, although the Australian Great Barrier Reef has shown considerable growth in recent years.”
- Note that the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) finds that pH decline has very likely emerged from natural variability. SROCC SPM A.2.5, “Open ocean surface pH has declined by a very likely range of 0.017–0.027 pH units per decade since the late 1980s, with the decline in surface ocean pH very likely to have already emerged from background natural variability for more than 95% of the ocean surface area.”

It would be more reflective of the literature to say here that “Many studies over the past decade have confirmed a global greening pattern (increase in LAI) attributable to rising CO2 levels, changes in climate, changes in nitrogen deposition, land cover change, and other factors.”

While the Zhu et al. 2016 study did find that 70.1% (+/- 29.4%) of the integrated global change in LAI was attributable to changes in CO2, most of the observed change in LAI is concentrated in the tropical forest regions of South America, Africa, and Indonesia, as shown in this report's Figure 2.1, reproduced from Zhu et al. In terms of the fraction of global land area influenced most by the factors considered in Zhu et al. 2016, effects on LAI from changing climate is the dominant factor (positive effects for 28.4% of land area plus negative effects on 4.7%, for a total area with dominant climate influence of 33.1%), followed by other factors not represented explicitly in the study or in the models (positive effects on LAI from other factors over 25.0% of land area plus negative effects over 5.3%, for a total area with other factors as the dominant effect of 30.3%), and then CO2 effects (23.2% of land area dominated by positive effects and 0.1% with negative effects, for a total of 23.4%). Since the report is focused on the U.S. it would be helpful to indicate the global context for the numbers reported.

The dominant factors related to changes in LAI over the U.S. (including Alaska) are land cover change (+LCC), climate effects (+CLI), other factors (+OF and -OF), and then CO2 (+CO2). There are more extensive regions where +CO2 is the dominant factor for the boreal forest zone in Canada. Given that, and given the explicit focus of the report on the U.S., it would be useful to call out in this section that the global greening pattern has distinct geographic variation in driving factors, and that over the target geography of the U.S. it seems to be dominated by factors other than increasing CO2. See my powerpoint slide 1 for a zoom on the area of interest from the Zhu et al. 2016 paper.

"Zheng et al. (2017) confirmed the pattern..." should be modified to say "Zhen et al. (2017) confirmed the pattern of observed greening..." As written, and in the context of the previous paragraph, the current text suggests that Zheng et al. 2017 confirmed the pattern of greening being related mainly to increased CO2, a factor which was not examined in their study.

Without the addition of the appropriate context in the preceeding paragraph (my notes 3, 4, and 5) the remainder of this paragraph could be misinterpreted to mean that the impacts of greening on air temperature are attributable back to a positive effect of CO2 on greening.

The sentence "Greening has been observed globally but Chen et al. (2019) noted that China and India were exploiting it through land management changes" is misleading. Chen et al. (2019) shows that China and India are *causing* the observed greening in large areas by intentionally increasing the land area occupied by forests (China) and increases in harvested area in croplands, mainly due to multi-cropping, heavy fertilizer use, and expanded irrigation (China and India). It would be more accurate to say "Greening has been observed globally, but Chen et al. (2019) represent a disproportionate fraction of the total greening trend, accomplished through intentional increases in forest area (China), and expansion of multi-cropping, fertilizer use, and irrigation in croplands (China and India)."

Given the changes suggested in these two paragraphs, it raises the question of whether the section title (CO2 and global greening) is itself misleading. That title wrongly suggests that all the content to follow is reflective of a direct influence of CO2 on the observed global greening trends, when the literature presents a much more *nuanced* interpretation.

It would be worth noting in this section that the multiple remote sensing-based datasets for LAI changes have remarkable differences, especially when comparing the figure 2.1 reproduced from Zhu et al. 2016 with the MODIS-based data record from Chen et al. 2019 (their figure 1). That means it is difficult to place a lot of confidence in the attribution of changes in different regions to different factors. See my powerpoint slide 2 for a comparison of the four datasets used in Zhu et al. 2016 and Chen et al. 2019.

The authorship for the Haverd et al. 2020 citation is not correct in the References section for this chapter. The correct citation is: Haverd, V., B. Smith, J. G. Canadell, M. Cuntz, S. Mikaloff-Fletcher, G. Farquhar, W. Woodgate, P. R. Briggs and C. M. Trudinger 2020. Higher than expected CO2 fertilization inferred from leaf to global observations. *Global Change Biology* 26(4): 2390-2402 DOI: <https://doi.org/10.1111/gcb.14950>.

A more recent and more comprehensive study (Keenan et al. 2023) reexamined multiple data constraints and concluded that the model used in Haverd et al. 2020 (CABLE) is outside the likely range of CO₂ fertilization effects, with higher CO₂ fertilization than indicated by multiple independent constraints. At the very least this more recent paper should be cited in the report, with text indicating that the central estimate from the TRENDY models is more likely to be in the range of observational constraints than is the CABLE result. As it stands the report suggests that the latest science indicates that most models have underestimated the fertilization effect, and the literature doesn't currently support that conclusion. See: Keenan, T. F., X. Luo, B. D. Stocker, M. G. De Kauwe, B. E. Medlyn, I. C. Prentice, N. G. Smith, C. Terrer, H. Wang, Y. Zhang and S. Zhou 2023. A constraint on historic growth in global photosynthesis due to rising CO₂. Nature Climate Change 13(12): 1376-1381 DOI: 10.1038/s41558-023-01867-2.

Zheng not in reference list. Do you mean Zeng?

"nearly double"? Why exaggerate? - it's a 76% increase. And they reported that future increase in GPP in extra-tropical northern hemisphere (e.g., U.S.) for [CO₂] from 300 to 600 ppm of 42%, or 32% more than previous predictions (not 76%).

Zhu also explained that "other factors (OF) not considered in models, such as forest management, grazing, changes in cultivation practices and varieties, irrigation and disturbances such as storms and insect attacks, can be a cause of mismatch between observed and simulated LAI trends.... OF contributes the most to the observed LAI trend over 25.0% (increase) and 5.3% (decrease) of the vegetated area"

This report is meant to focus on the U.S., so it would be more appropriate to discuss greening trends in the U.S. Fig. 2.1 shows that the trend in LAI across much of the U.S., with the exception of the Southeast, is less than the global average. Negative OF effects are mainly found in northern high latitudes (e.g., Alaska). Growing season warmth is the dominant factor in cold regions (10.1038/s41558-018-0258-y). Significant browning also is occurring in parts of Alaska (10.1175/EI-D-20-0025.1)

Greening of the Arctic can have important adverse consequences. Direct observations support that warming and increased vegetation cover in the Boreal-Arctic region showed a "robust increasing trend of CH₄ emissions (+8.9%) with strong inter-annual variability. The majority of emission increases occurred in early summer (June and July) and were mainly driven by warming (52.3%) and ecosystem productivity (40.7%)." Yuan et al 2024 (10.1038/s41558-024-01933-3).

Wang et al 2020 (10.1126/science.abb7772) report a decline over recent decades in CO₂ effects on global photosynthesis, possibly due to increasing nutrient interactions or interactions with effects on LAI. The two summary statements provide an extremely narrow and misleading view of "direct impacts of CO₂ on the environment" (the chapter title). The most obvious direct impact of CO₂, in the context of climate change, is its role in global radiative forcing, which is covered in the next chapter but not mentioned here. The chapter should at a minimum be retitled, but better yet combined with the following chapter which discusses other aspects of increasing CO₂.

It is misleading to state that ocean pH levels are within the range of natural variability. This statement is not true on the timescales governing the impacts of ocean acidification on ocean ecosystems, fisheries, and other processes.

The summary should note that CO₂ fertilization effects are limited by the availability of other critical plant nutrients (Nitrogen, Phosphorous). The fertilization effect is also constrained by higher temperature affecting photosynthesis[9]

The attribution of greening to primarily CO₂ fertilization is questionable as per recent research. Specifically, in the Northern high latitudes (where the greening is most prominent), increases in temperatures due to climate change has been shown to provide the best explanation[10]. In the sub-Saharan region reforestation efforts and changing precipitation patterns lead to some of the observed greening (the great green wall) [11]. The attribution to CO₂ fertilization should be qualified by noting the other present and emerging constraints.

This summarization ignores the compound effects of temperature, moisture and CO₂ fertilization in assessing the impacts of CO₂ increase on vegetation and crop yields. Many studies have shown that [12]. Making note of these compensating factors is required for a balanced view on CO₂ fertilization effects on plants.

The attribution analysis in the Chen et al. 2024 paper is very sensitive to the choice of multiple regression vs. partial correlation (their figures 3 vs S7, respectively), and in both cases they seem to misattribute the significant increases in LAI in India and China to CO₂ rather than to changes in landcover and cropping practices. This kind of regression-based attribution is less informative than the model-based inference used for example by Zhu et al. 2016. The description of sensor calibration issues in this paper is also very cursory. It would probably be better to refer to the review paper of Piao et al. 2020 to support the claim of continued greening. Piao, S., X. Wang, T. Park, C. Chen, X. Lian, Y. He, J. W. Bjerke, A. Chen, P. Ciais, H. Tømmervik, R. R. Nemani and R. B. Myneni 2020. Characteristics, drivers and feedbacks of global greening. *Nature Reviews Earth & Environment* 1(1): 14-27 DOI: 10.1038/s43017-019-0001-x.

The section 2.1.2 (Photosynthesis and CO₂ levels) lacks coherence. It seems to be a collection of uncontroversial points about the ability of increased CO₂ concentration to stimulate plant growth and reduce water loss through stomates. Figure 2.2 seems intended to show that the current levels of CO₂ are not high compared to levels experienced in Earth's deep geologic past. A balanced treatment of the topic might call out the rate of change in CO₂ concentration from human-caused emissions, and how both that rate and the absolute levels diverge radically from rates of change and ranges of variability over the past hundreds, thousands, and hundreds of thousands of years. See my powerpoint slide 3 for an example set of figures that might be included.

Much of this information in this section is appropriately covered in chapter 9 on agriculture. Chapter 2 purports to have a wider focus (global and environment responses), so it should not dwell on responses of individual crop plants (crops account for only 15% of global GPP). There has been plenty written on ecosystem response to eCO₂, but evidence such as Fig. 2.3 is not relevant. All analyses of direct eCO₂ effects reveal an overriding interaction with other environmental factors (nitrogen and temperature), and global models show that eCO₂ only partially compensates for the negative effects of climate change on ecosystem carbon response.

Zhang, 2025 (10.1016/j.ecolind.2025.113762) reported that although vegetation cover was increasing, resilience against external disturbances (drought, heatwaves, wildfires) has simultaneously declined.

Why use studies based on satellite sensors? I'm quite sure there are studies (again, out of Stanford) that use historic yield data (county-scale USDA data and global FAO data) with associated temperature and precipitation data. Those analyses do not agree with your findings here, I think. But, we can certainly pose these questions to our scientists that study and develop land models and develop a report based on all available data. I'll also note that for sometime data synthesis wasn't considered fundamental science and was therefore largely ignored. Enabling the researchers to conduct robust data analyses on this and other topics would be largely welcomed.

Chen et al. (2024)[13] conclude that "In the attribution analysis of LAI trend and growth rate trend, there were some differences between multiple linear regression model and partial correlation analysis at high latitudes in the northern hemisphere. Partial correlation analysis showed that LAI trend and growth rate trend in this region were mainly affected by temperature and radiation, while multiple linear regression suggested that CO₂ was the dominant driver. The results of the partial correlation analysis seem more reasonable because some previous studies have shown that vegetation change in the high latitudes of the northern Hemisphere is mainly positively affected by climate warming. Multiple linear regression model performed relatively poorly in this region and might not fully identify the contribution of individual drivers. In addition, our model does not include the contribution of land management, which has been highlighted in some previous studies. Of course, the contribution of land management to LAI trend and growth rate trend may be implied in other drivers, such as the positive contribution of CO₂ to LAI trend in PP and PN areas".

The graph is not relevant to the discussion. It should only, at most, cover the time period since the last glacial maximum, which occurred ~20 kyr BCE, and common practice is to concentrate on the last 1000 years.

All data is interesting and useful for perspective and understanding. But isn't the main question whether we are driving up CO₂ and temp at a rapid pace in the post-industrial era? This graph does not help answer that question.

It is misleading to show (only) a graph of CO₂ levels over hundreds of millions of years. These timescales are generally not relevant to processes and issues surrounding anthropogenic CO₂ increases. For example the authors in multiple places make statements about CO₂ levels during the last glacial maximum, but those fluctuations are undetectable on a graph with such a long timescale.

A simple calculation will show us how misleading this figure is. It shows that over 600 Million years CO₂ changed by around 6000ppm. That is a rate of change of 0.00001/yr; CO₂ changed from 275 to 430 in the past 175 years, that is rate of change of 0.88ppm/yr. A change in the rate of over 10⁵ in magnitude - there lies the problem. We are seeing a rapid increase in CO₂ that has never been witnessed and the ecosystem and human society (which is at best 10K years old), may not be able to adapt to this rapid change.

This again suffers from not acknowledging the effects of compound and often compensating phenomena that is occurring with the on-going climate change. For example [14] note that much of the Midwest any benefit from CO₂ fertilization will be negated by temperature increases. [15] note that "Our results show that long-term physiological acclimation dampens the initial stimulation of plant net carbon assimilation to elevated [CO₂], and of plant water use to warming."

The report suggests that the topics of CO₂ fertilization and increased water use efficiency are not adequately treated in recent IPCC reports. In IPCC's AR6 WG I report there is an entire chapter devoted to an assessment of carbon cycle processes (Chapter 5, Global Carbon and Other Biogeochemical Cycles and Feedbacks). This is precisely where one would expect to find information about CO₂ fertilization and water use efficiency. In the Executive Summary for the chapter is the following bolded headline: **Increases in atmospheric CO₂ lead to increases in land carbon storage through CO₂ fertilization of photosynthesis and increased water use efficiency (high confidence)**. The associated Executive Summary text includes reference to two figures, three chapter sections, and a cross-chapter box all dealing directly with this topic. The Executive Summary text also references the important topic of nutrient dynamics and their interactions with fertilization and ecosystem-climate feedbacks, a critical nuance of the interaction of CO₂ and vegetation productivity that is ignored in the report reviewed here.

Cheng did NOT report "increased plant growth"; they reported increased GPP. The distinction is fundamentally important, has been recognized for decades, and is completely ignored in this chapter.

Stating that increased aridity in drylands will not lead to decreased productivity seems a bit questionable. We can point to precipitation gradients from high to low precipitation that supports forests to grasslands to shrublands, respectively. Less water in general will mean less productivity; this can be seen in different forest compositions as well. The authors cite Zhang et al. (2014), but Zhang's main point is that the direct CO₂ effect may be causing greening in drylands that offsets the decreased precipitation. This may be more specific to dryland vegetation, and Zhang et al. specifically state that this finding is relevant to north-east Brazil, Namibia, western Sahel, Horn of Africa, and central Asia.

Section 2.2.2 (Coral reef changes) has a strong focus on past examples of early investigations that are later updated. There is also a note about the difficulty of publishing negative results, with a quote that this pattern "is true across all of science". Given the objective of this report, I suggest a shift in tone away from complaints about the kinds of papers that do and don't receive media attention, and instead highlight the latest synthesis of results about the likely future of coral reefs. A relatively recent synthesis paper (Cornwall et al. 2021) in a well-respected journal (PNAS) based on collated data from 233 locations worldwide projects that 37% of reefs will stop accreting and thus fail to keep up with sea level rise by 2050 under the low emissions RCP2.6 scenario, and no reefs would be able to accrete at a rate to stay ahead of sea level rise by 2100 under either RCP4.5 or RCP8.5. This analysis finds that most of the loss of net accretion rate is due to bleaching events, and a minority of the impacts are due to "direct physiological impacts of ocean warming and acidification on calcification or bioerosion". C.E. Cornwall, S. Comeau, N.A. Kornder, C.T. Perry, R. van Hooidonk, T.M. DeCarlo, M.S. Pratchett, K.D. Anderson, N. Browne, R. Carpenter, G. Diaz-Pulido, J.P. D'Olivo, S.S. Doo, J. Figueiredo, S.A.V. Fortunato, E. Kennedy, C.A. Lantz, M.T. McCulloch, M. González-Rivero, [...] & R.J. Lowe, Global declines in coral reef calcium carbonate production under ocean acidification and warming, *Proc. Natl. Acad. Sci. U.S.A.* 118 (21) e2015265118, <https://doi.org/10.1073/pnas.2015265118> (2021). acidification is not a misnomer...the word literally means to make something more acidic, which is what is happening. The authors may choose to argue that the term is misleading since the oceans are slightly basic, but that is not the same thing as a misnomer.

It is misleading and largely irrelevant to discuss ocean pH levels tens of thousands or millions of years ago, because that timescale is not relevant to the impacts associated with anthropogenic ocean acidification on ocean life. It is well documented that recent changes in ocean pH are happening ~100 times faster than natural fluctuations prior to human CO₂ emissions, and marine species must adapt to changes in conditions on timescales of a few of their lifetimes, which is clearly not millions of years.

The fallacy of these arguments in terms of pH changes and evolution is that the changes described in this paragraph occurred over millennia and the evolutionary process had time to adapt; here with climate change we are talking about changes in our lifetime, the speed of change is the issue. This will lead to collapse of some ecosystem and by the time adaptation takes place it will be millions of years and in a different climate - not the one we have now and that enabled the rise of humans.

I do not disagree with this observation of a decline effect, and I have seen it in some of the early biomass energy analyses that appeared in prominent journals and were then corrected over a few years. While it is unfortunate that some try to grab headlines with unsupported assumptions, it does seem that other researchers tend to provide counter arguments and analyses fairly quickly, indicating that the system does in fact work fairly well.

Similar to previous comment--changes in marine life over hundreds of millions of year has little relevance to the survival of marine species on decadal timescales due to anthropogenic ocean acidification. Are the authors trying to suggest that U.S. society would be well served by going back to conditions during the Jurassic?

This material is repeated in chapter 9 where it belongs. Here, it would be more appropriate to focus on how eCO₂ interacts with drought on ecosystem response (e.g., 10.3390/atmos12020212)

It is misleading to separate the photo-chemical effects of CO2 from the temperature effects. Extreme heat is hard on plants, causing them to lose water, close stomata, etc. It depends on the plant and the degree of heat. **More research is needed to understand how the temperature (mean and variability) affects plant productivity and resilience.**

Again it is misleading to separate the CO2 and the temperature effects on the oceans. The warming surface waters is having significant impact on ocean fish and habitats due to the overall increase in global temperatures

The misuse of RCP8.5 as business as usual is acknowledged. However, this was never intended to be a no-policy or business as usual scenario but as a high-end baseline scenario. When dealing with interaction of physical systems with socio-economic projections (which tend to be highly uncertain and policy dependent), the development of this high baseline scenarios is intended to explore the uncertainty ranges that represent a high-end scenario[16,17]. As any engineer would acknowledge, this is a prudent approach when dealing with L3 and L4 type deep uncertainties and provide valid envelopes for assessing uncertainties and risks from high impact events/hazards. The rest of the statements here are uncertainties acknowledged by the climate scientists and included in developing projections and discussing the results[4]. Does the IPCC downplay the role of sun in climate change? The IPCC includes sun variability in all its assessments from the beginning and has been acknowledged as a potential but insignificant contributor.

The IPCC probably discounted the results reported in Connolly (2021) because that study included methodological errors that were documented in several subsequently publications, which the authors do not acknowledge. A serious assessment of TSI would not cherry-pick a single study, especially one that has been shown to include serious errors.

The study by Connolly et al. 2021 uses a linear regression approach to estimate the amount of variability in surface temperature trends that could be explained by total solar irradiance time series. Their approach is to first model the temperature trend with TSI as the dependent variable, and then compare the residuals from that fit to anthropogenic forcing factors. This is an obviously biased approach, and in fact a full paper was published the following year (in the same journal) laying out the erroneous methods and the faulty conclusions they produce (Richardson and Benestad 2022). Richardson, M. T. and R. E. Benestad 2022. Erroneous use of Statistics behind Claims of a Major Solar Role in Recent Warming. Research in Astronomy and Astrophysics 22(12): 125008 DOI: 10.1088/1674-4527/ac981c.

It is unclear what the authors mean by "other natural sources of energy imbalance". If the authors are aware of a plausible additional source of energy imbalance they should state what it is rather than making vague statements without providing any evidence that such sources might exist.

This is one of several places where the authors discuss the CO2 levels at which C3 plants begin dying in the context of the last glacial maximum. This is misleading, because there is no evidence that CO2 levels would have continued falling below the levels of the last glacial maximum, and irrelevant to the stated focus of this report, because they rebounded to 280 ppm many centuries before human activities began producing large amounts of CO2.

- "Instead, the IPCC has created various sets of scenarios meant to span a plausible range of possibilities"
- Suggest changing "created" to "assessed" as the scenarios are created by the science community not the IPCC.

The oceans and land surface absorb more like 60% of CO2 emissions. The 50% figure is repeated multiple times in the ensuing pages and should be corrected.

- “The IEA trends, which are based on plausible extrapolations of current economic and demographic trends, run below the entire envelope of RCP projections, implying not only that RCP8.5 is dubious, but that even lower emission scenarios are unlikely.”
- Burgess compares IEA to the two highest SSP-RCP scenarios, not to the full range. The last sentence of the paragraph is incorrect – the range in Burgess is only no climate policies which doesn’t include the lower RCPs.

Please see above. The business-as-usual may be a misnomer but this is a 95% case that is typically included in any type of prudent uncertainty analysis, in particular given the difficulty of predicting the evolution of socio-economic and political conditions over the next 100 years. It should be noted the difference between RCP8.5 and RCP4.5 for mid-century conditions that is of particular focus for adaptation studies is not significant and most of the divergence in these two scenarios occurs later in the century.

- “As of 2023, global CO2 emissions have been tracking well below SSP7.0 and are even below SSP2-4.5.”
- Note that near-term emissions are not necessarily a good predictor of long-term emissions, as the latter will depend on changes in population, demographics, technology, and policy that do not have the same influence on near-term emissions.

Section 3.2.2 (The carbon cycle relating emissions and concentrations). There is no new information or analysis presented in the chapter, and it relies heavily on Global Carbon Project information. Figure 3.2.3 is described as showing a seven-fold difference in the recent trend in land carbon sink estimates across land models, and this is given as a potential driver of uncertainty in future carbon cycle and climate change predictions. Variation among models is well known and is one of the reasons exercises like CMIP and GCP rely on multi-model ensembles when assessing the state of the science. The distribution of results looks fairly typical in this diagram, with a strong central value around 1.3 to 1.3.

Regarding the uncertainty in the land sink, a primary reason for this uncertainty is that the primary response of photosynthesis to CO2 does not predict C sequestration because of strong interactions between CO2 and climate, nutrients, stand dynamics, and other factors. That is why the almost complete focus in this report on crop plants and plant responses in greenhouses does not inform us about "CO2 uptake by land processes"

Yes, CO2 uptake by land processes have uncertainty associated with them. It's worth noting that DOE researchers (many of whom are retired now) were world-leading and making progress in this area, but nearly all work on CO2 uptake and emissions stopped 10-15 years ago due to political pressure and political concerns. The Carbon Dioxide Information and Analysis Center at ORNL, now cancelled, was a main contributor to the Global Carbon Project. Now the US is woefully behind and ceding expertise on this to the Europeans (as cited in this report). We are also ceding expertise on carbon monitoring via satellites to other countries. There's nothing necessarily wrong with this if this is where the US wants to go, but it's important to recognize that we have lost significant capacity due to policy changes over many years. That the dynamic vegetation models need more development is acknowledged and is a defining challenge for Earth System Modeling for the next decade.

The final sentence on this page is misleading and confusing as written. Most studies of the land carbon sink suggest that the rate at which it is increasing is declining, and several studies suggest that the ocean sink is declining. The authors should also explain the relevance of their statements here, because it isn't clear.

- “In summary, while there is clearly warming in the land record, there is also evidence that it is biased upward by patterns of urbanization and that these biases have not been completely removed by the data processing algorithms used to produce climate data sets.”
- Quantitative info would be helpful here. How large is the warming? How large might the bias be?

As noted, Parker[18,19,20] has investigated the Urban effects on temperature records. The finding establish that by comparing warm and wind conditions world wide that the impact is negligible. However, as noted by authors, this literature hasn't progressed much over the last decade and much more attention needs to be paid to this question by employing newer models, datasets and analytical techniques available to us at present.

There is no quantification of the effects of TSI and volcanic aerosols that would lead to modifications of the radiative forcing shown in the figures

Many of the arguments and references are dated. Further, the challenge posed is to prove a negative, i.e. that the record used by AR6 is not biased by urban heat island effects. On the contrary, while verbally stating uncertainty, the authors cannot make a claim that the AR6 statement is false. Even if one were to accept the Soon, et al value of 0.89 deg C/century, the focus on the land surface warming completely neglects the contribution of the oceans to global surface temperature change, which must be considered in any discussion of surface temperature change.

More accurate to say "because their effect remain largely unknown". Good examples include natural aerosols (sea salt, dust, biogenic aerosols). Are there others to mention? **More research is needed to understand radiative effects of both natural and anthropogenic sources of radiative variability throughout the atmospheric column.**

What scenarios are the models using in this figure?

Vegetation is only one way that CO2 is accommodated by land processes, the other is through soils and microbial processes Microbial dynamics is complex and challenging to understand but may also be a way to boost CO2 absorption by soils (which also enriches the soil nutrients!). **More research is needed to better understand how plants and soil systems remove CO2 from the atmosphere.**

More research is needed to improve the understanding and representation of land systems, carbon and nutrient fluxes in models.

Carbon uptake by oceans and ocean ecosystems is less well studied and modeled. The lack of spread of carbon in ocean models may result from insufficient information, ocean biogeochemistry, ecosystems and model development. **More research is needed to study and model carbon, nutrient and ecosystem processes and dynamics in ocean models.**

More research is needed to map warming trends in urban, non-urban and other environments and to ensure accurate representation of regional and global trends in temperature.

- The Chapter Summary doesn't really capture the full tax of the chapter. Would suggest: Defining ECS/TCS, reporting values for ECS and uncertainties/methods, then reporting values for TCS, preferably with a sentence on what those values imply
- “This raising of the lower bound is less justified; evidence since the AR6 finds the lower bound of the likely range to be around 1.8°C.”
- This isn't really discussed comprehensively in the chapter.

- “The climate’s response to increasing concentrations of CO2 is central to the scientific debate on anthropogenic climate change”
- Suggest rewording this to, “The magnitude of the climate’s response...” As currently worded it could be a bit misleading since the qualitative effect (i.e. increasing CO2 concentrations lead to increases in global average temperature) is not disputed – the uncertainty is around the magnitude of the effect.
- The text cites Dayaratna (2016), but this should be a reference to Dayaratna (2017) as listed in the reference section.
- “If ECS is very high (above 4.5°C) immediate aggressive emission controls become more imperative, whereas no CO2 emission controls are economically justifiable for ECS below 2.0°C (Dayaratna et al. 2016, 2020).”
- This could use additional clarification as there are low and now carbon technologies that can be economically justified based on cost of energy alone, depending on technology, location, etc.

- “Obtaining a precise estimate is impossible, so policy making needs to account for the uncertainty.”
- The Social Cost of CO2 (SC-CO2) as used by the USG in regulatory impact analyses has always accounted for uncertainties in the ECS. EPA (2016) used a probability distribution for the ECS calibrated to IPCC AR4 findings (the most recent values available at the time) to harmonize the approach for the three models used (FUND, DICE, and PAGE). EPA (2023) updated the SC-CO2 in response to NAS recommendations (NAS 2017) to include a much fuller representation of the uncertainties in both ECS and TCR, and utilized a modular approach incorporating the Finite amplitude Impulse Response (FaIR) climate model, a reduced complexity climate model, with ECS and TCR distributions calibrated to IPCC AR6 to represent this uncertainty.
- The Dayaratna (2017 & 2020) papers referenced here analyze sensitivity of a subset of the older models used in EPA (2016) to just ECS estimates. It would be helpful to address the advances in the broader literature that are discussed and represented in EPA (2023) as the focus of this report is on literature published since 2020.
- EPA (2016) “Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866 - Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf
- EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf
- NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” <https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of>

The inclusion of a paragraph with high-level summary statements about climate policy here is confusing and inappropriate. This content belongs in chapter 11.

- “Because of concerns about model tuning and the high sensitivity to cloud parameterizations, the IPCC AR6 (2021) did not rely on climate model simulations in their assessment of climate sensitivity, relying instead on data-driven methods.”
- AR6 WGI 7.5.5 states this a little differently. IPCC’s assessment wasn’t “directly informed” but “ESMs remain essential tools.”

We can all agree that there is a desperate need for developing higher-resolution climate models that can get to cloud resolving scale so that we can represent the cloud feedbacks correctly in the model and avoid uncertainties from parameterization and scale dependency of the parameters. This doesn't make these models useless. The models provide directions for further improvements and necessary changes to reduce the uncertainty bands over the ECS.

- "For AR6, the IPCC placed primary weight on the results of Sherwood et al. (2020)..."
- The IPCC assessed a large number of studies, not just Sherwood (2020).

The point about observed global temperature trends being consistent with both high-ECS high-aerosol and low-ECS low-aerosol worlds is an important one. It would be good to acknowledge that uncertainty in ECS is not just due to uncertainties in climate models, but also the lack of accurate measurements of pre-industrial aerosols and thus anthropogenic changes in aerosol forcing. And this uncertainty cuts both ways--if we live in a high-ECS world that has been "masked" by strong aerosol cooling, reducing air pollution could result in rapid warming (and this may be linked to the "hot model" problem as well).

The point about ECS values derived from past climate states (especially cooler ones) possibly not being totally representative of the current climate is another good point, one that would be good to acknowledge in their earlier and later discussions about uncertainty and the rationales for emissions reductions (e.g., on page 26 and in Chapter 11).

The databased approaches have mostly been robust with changes at the high end around 3-4C and at the low end around 1.8 to 2.5C as noted in the chapter. It will be challenging to make this range shorter given the data requirements and uncertainties in data over paleo/holocene periods. It seems reasonable to estimate that we may have ECS in the range of 3 to 4K (higher than 3.5K being less likely [21]) at the higher end and this should not prevent us from planning and thinking on ways to prevent this possible scenario as it could have major consequences for humans across the planet.

The statement "TCR is more generally related to peak warming and better constrained by historical warming, than ECS." requires further context. While true that the "peak warming" rate achieves a maximum around 70 years, temperature increases continue for several centuries and approaches the ECS value asymptotically. Further, the Lewis (2023) arguments were placed in context by Sherwood and Forest (2024), that identified multiple recent ECS studies that showed, collectively, that the PDF in their original Sherwood, et al paper could not be narrowed. Additionally, the reference to Sherwood et al (2020) is incorrect. It omits many authors and the authors that are listed are not in the correct order.

The relatively shallow treatment on TCR relative to ECS here is puzzling, since the authors acknowledge that it is better constrained, and it is also a more relevant value for projected warming over the next several decades. The first sentence here also describes it as an observational constraint, but it is not, it is a metric that can be produced from either data or models (or both), and climate models are routinely used to run TCR experiments.

"This practice" - need to clarify whether this refers to "emergent property" or discarding. I believe the authors mean the latter, but it should be made more clear

"assumed positive cloud feedback" - this is an emergent property too, based on simulation/observation. Should be rephrased to not use the word "assumed". **Further research is needed to better understand and model how clouds change with temperature and what the feedback effects are on the radiative balance. Further research is needed to narrow the uncertainty on climate sensitivity, both using models and observations.**

- It would be helpful for the reader for this chapter to start with a summary figure (e.g. like IPCC AR6 WG1 – SPM.1 or Fig. 3.4). Currently, the chapter jumps right into details that will be difficult for anyone who is not a climate scientist or already versed in these issues to understand or interpret.

A more accurate title of this chapter would be "deficiencies in climate models" because the authors focus almost exclusively on processes and features that models have struggled to reproduce, rather than a balanced assessment that also indicates what these models do well.

The models range over a factor of three in ECS comparing the most sensitive to the least sensitive models. However vast majority of the models are in 3 to 3.5K sensitivity range and it is probably not correct to assign all models the same amount of importance, given the fact that some of institutes participating in the exercise have different levels of capacity to develop and test models.

- "Figure 5.1 CMIP6 Average surface temperature range across 33 models and standard deviation using SSP5-85 scenario."

- SSP5-85 is an excessively high scenario that is not representative of current expectations of emissions projections. Suggest changing the figure for on with data from a less misleading and more representative scenario.

- There have been extensive published comments and responses on the approach used in Scafetta (2023). Can these be reflected here?

- G.A. Schmidt, G.S. Jones, and J.J. Kennedy, "Comment on "Advanced Testing of Low, Medium, and High ECS CMIP6 GCM Simulations Versus ERA5-T2m" by N. Scafetta (2022)", *Geophysical Research Letters*, vol. 50, 2023. <http://dx.doi.org/10.1029/2022GL102530>

- N. Scafetta, "Reply to "Comment on 'Advanced Testing of Low, Medium, and High ECS CMIP6 GCM Simulations Versus ERA5-T2m' by N. Scafetta (2022)" by Schmidt et al. (2023)", *Geophysical Research Letters*, vol. 50, 2023. <http://dx.doi.org/10.1029/2023GL104960>

- Z. Hausfather, K. Marvel, G.A. Schmidt, J.W. Nielsen-Gammon, and M. Zelinka, "Climate simulations: recognize the 'hot model' problem", *Nature*, vol. 605, pp. 26-29, 2022. <http://dx.doi.org/10.1038/d41586-022-01192-2>

- S. Jain, A.A. Scaife, T.G. Shepherd, C. Deser, N. Dunstone, G.A. Schmidt, K.E. Trenberth, and T. Turkington, "Importance of internal variability for climate model assessment", *npj Climate and Atmospheric Science*, vol. 6, 2023. <http://dx.doi.org/10.1038/s41612-023-00389-0>

- "Spencer (2024) has also provided a useful summary of the Model-Observation mismatch by comparing trends in surface temperature data products with those in individual climate models, as summarized in Figure 5.3; most climate models show substantially more warming than the observations since 1979."

- It is worth noting that IPCC projected temperatures do not use all models and instead focus on those that best reproduce observations. So while some models may show warmer or cooler temperatures than observations, that does not imply that projections from large assessments reflect those biases.

Scafetta (2023) has been widely criticized in the scientific literature for its methods and conclusions. These results should not be presented without acknowledging these concerns, or better yet, the authors should attempt to survey the literature on this topic rather than presenting results from a single controversial paper.

Spencer (2024) is not a peer reviewed journal paper and is not really appropriate to include here when there are many papers on this topic that have been peer reviewed.

While this analysis for the CMIP6 model set is accurate and focuses on a dataset that has shown higher ECS than previous iterations. It should be noted the models have exhibited considerable skill in predicting the subsequent GMST warming[22]. The criticism of the CMIP6 based high ECS models may be premature and probably will have to wait additional time before passing judgement. As noted in [22] these models have shown considerable skill when evaluated on their projections over the past 30-40 years after the projections were published.

The statement that the signal for anthropogenic greenhouse warming emerges first and most strongly is not supported and is inconsistent with my understanding of climate dynamics. The following sentence is also dubious (and probably backwards) since models run with observed surface temperatures tend to produce much better mid-tropospheric temperature simulations.

In most places the authors correctly describe the discrepancy between models and observations as a mismatch, which is appropriate because observations of mid-tropospheric temperatures are also subject to uncertainty (as indicated in the error bars in Figure 5.4). This is one of the reasons for the IPCC confidence assessment noted in the following paragraphs. However, here and in a few other places in this section the writing implies that differences can be solely attributed to model deficiencies.

A recent study attributes the bias to inter-annual availability and residual bias in the satellite record. The pre- and post 2000 have temperature records from two separate satellites and the discrepancy in the trends needs to be resolved[23]

- “Hence, we assess with medium confidence that CMIP5 and CMIP6 models continue to overestimate observed warming in the upper tropical troposphere over the 1979–2014 period by at least 0.1°C per decade,”

“Notably, despite the accumulation of evidence of excess model warming the IPCC assigns only medium confidence to the existence of a warming bias.”

- This reflects a more general issue with IPCC confidence statements where the inclusion of a quantification reduces the confidence they include. Here the full statement with the quantification of 0.1C per decade is assigned medium confidence whereas a statement about the existence of the bias without a specific quantification would receive higher confidence.

This section should be combined with the previous one as it is really just elaborating on the same discrepancy between climate models and observational estimates of tropospheric temperatures.

This is challenge we need to face and work on improving the parametrizations. The new era of super high resolution models would resolve the complex interactions of turbulence, transport and clouds and will provide less uncertainty[24]. However, this can't be used to invalidate the entire set of models, the models are performing remarkably well given the complex system that is being modeled. It should be noted the models do cover the range of the observations and it is not outside the envelope of model predictions.

- Does this update with data through 2024 use the same models that Christy and McNider (2017) used, or does it use updated versions for the models as well? This would be helpful to clarify here and in other places where figures are produced with updated data.

- “The IPCC AR6 did not assess this issue.”

- Was this assessed in IPCC AR5? Many of the citations here could have been assessed then. Is there any more recent evidence on these issues that should be referenced here?

There has indeed been considerable controversy about this particular metric. It is curious that the authors choose to cite two older papers here (2008 and 2009) rather than the rich recent literature, especially since they went to the trouble of updating on of their graphics with 2024 data. Recommend including a more balanced assessment of this discrepancy, it's potential causes, and recent efforts to address it, as well as noting that climate models are able to accurately capture many other aspects of climate change.

This entire section is very misleading as it cherry-picks a specific result and takes it out of important context. The reason why stratospheric cooling has slowed (and, at least in one study, even warmed) in the past two decades is due to the recovery of the ozone layer. This is clearly stated in the Philipona et al article cited by the authors and in the IPCC report. Additionally, satellite-based estimates of stratospheric temperature (which is data the authors highlight in the previous section) do not show the same trends. This section should be removed or amended to note that stratospheric temperatures are influenced by multiple factors and that a comprehensive analysis of stratospheric temprature trends is fully consistent with those projected under climate warming scenarios.

- Are there more recent papers or data available? All the info here is AR6 or pre-AR6, but more recent years have shown more surface warming. It would be interesting to show stratospheric temperatures for these more recent years as well to see how this relationship holds.

- Trends in snow cover depend on both changes in precipitation and changes in temperature. It would be helpful if these were discussed separately rather than showing the net effect for one region/season. Part of the problem here may be which part of the stratosphere is sampled and the importance of interannual a variabilities in the lower part of the stratosphere. [25] have shown that including the stratosphere as defined from 25 to 50km there is high confidence that the cooling signal caused by CO2 increase is detectable and beyond the noise levels of the natural and inter annual variability in the lowest part of the stratosphere. We should put this debate to rest.

Many observational studies have shown that snow cover is decreasing, and have explained why it is more meaningful and useful to look at spring trends in snow cover, as well as why observations of snow cover can be uncertain.

The authors provide a relatively accurate survey of results regarding hurricane numbers and landfall frequency, which have indeed not shown any trends. But their analysis of hurricane intensity, which has been shown in many studies to increase, is lacking...the chart showing just estimated windspeeds of the top ten landfalling storms is really weak given the analytical talents of the author team. They also do not provide any discussion of the physical basis for why hurricane numbers may not be changing while the intensity of the strongest hurricanes is expected to increase, nor analyze any data in the context of those conclusions. Given the large uncertainties in obtaining data over much of the Northern Hemisphere, using a smaller regional analysis to discount the models may be inappropriate. We should that this remains a question we need to resolve developing better datasets with more seasonal and sub-seasonal coverage to test the model on a global scale

Some of the early work on this topic was done by researchers at Stanford. But there are plenty of other papers. Here's one that came up in a quick search: <https://www.pnas.org/doi/10.1073/pnas.0906865106> Contradicting a number of large meta-analyses on the topic of decreased yields with increased temperature is ok. That's what science is all about. But it's going to have to be done in a more robust way than a couple paragraphs here with one or two citations.

This statement from [26] refers to the fitness of global scale models to resolve regional scale features and argues for developing model at higher spatial resolutions. Using downscaling and other techniques additional insights can be gained at regional scales and provide information for a set of 'purposes'. However, we should work on getting to regional and local scales with GCM as quickly as possible. The analysis presented of the IPCC AR5 figure, Fig 5.6 in the current document, is outdated and should be removed. The issue IS addressed in the AR6, but not graphically, in the text reproduced by the authors. If the section is retained, it should be moved ahead of Section 5.3 to present the material in the correct order chronologically.

The text and figure refer to 33 models, which would include the best and worst. How much does the uncertainty/range change for a subset of best-performing models?

How many models are included in each case?

How are the lower and mid-troposphere defined?

"excess amplification" - amplification of what? And Figure 5.6 shows tropics, is this bias only tropical?

Further research is needed to improve how models represent clouds and dynamics; additional observations are also needed to improve these representations.

Further research is needed to improve how models represent planetary albedo to align with observations.

- This chapter relies solely on observations and does not include other lines of evidence, it would be helpful to discuss what these other lines of evidence indicate to avoid introducing potential biases (e.g. what do process based lines of evidence show?)
- The chapter summary does not fully capture the chapter or the science. Suggest talking about the extremes affected by climate, the extremes not affected by climate, and those where the data isn't sufficient to establish a trend.

- "Over geologic time the climate system has generated an (essentially) infinite variety of weather patterns and extremes..."

- Just because an event occurred before humans does not mean humans are not influencing the frequency or intensity of such events now. Additionally, if something has happened in the geologic record, but humans have never experienced it before, they may not be prepared for such an event.

This is very important. I have not dug into the data on extreme storm data (both numbers and intensity).

Getting researchers together that disagree on a topic, analyze the data, and publish findings together can be very productive. DOE could sponsor a workshop and bring together a broad range of experts and find answers to extreme weather trends.

I conducted some analyses on wildfire years ago. I saw the bias in the university textbooks and in the wildfire working groups, who essentially went by textbook teachings. It was rare that people went back to the original data. The last time I checked the actual data (a good 10 years ago), I found that...you're correct...the number of fires had not changed much. What does seem to be changing is that the extent of fires has grown, and this is mostly attributable to hotter and drier conditions. I do not believe there is more fuel load now than there was before the US was settled. Arguing that harvesting will decrease fire is nonsensical; you have no idea where the lightning is going to strike and subsidizing the thinning of all forest in the western fire zone would be cost prohibitive. I think we need to stop using wildfire management as a justification for harvesting. If we want to harvest more, than do it, and stop using fuel load arguments (which is more of a concept than proven reality) as a reason to do it. The biggest issue here is encroachment of housing communities into the Wild-Urban Interface (WUI) and how we want to handle that with policies. Fire is really only bad if it's burning someone's house down. Otherwise, it's a natural progression in forest dynamics. Sources: Campbell et al. 2012. doi:10.1890/110057.; Schoennagel and Nelson. 2011. doi:10.1890/090199.

Long term persistence is not a recognized property or phenomenon associated with rainfall data. The use of such a statistical technique, especially one that is not widely recognized or used in the hydroclimate community, demands additional justification.

Looking for trends or estimating trends in extreme events in current and future climate is not necessarily an attribution study. Estimating frequency, duration and intensity of events helps understand the changing range of the hazard (if there is one). An attribution would be to find to what extent a particular event is influenced or affected by increase in CO2. I would consider these two not to be the same.

Attributing any single event to changing climate is perilous, agreed.

As noted by [26] there is not yet any strong evidence that LPT is a fact

- The figure heading has “@RyanMaue” in the title. Looks odd to have a social media handle in the figure. Is the source peer reviewed?

- Insufficient data is different than no effects. It would be helpful to be clear in instances like this whether a conclusion is because the data supports it, or because there is insufficient data to say the opposite.
- Could you also show a similar table with hurricane precipitation?
- The last two paragraphs show findings from NCA4. With the interest in focusing on recent literature, what does NCA5 say about these issues? Does it not cover this issue, does it say the same thing, does it contradict this finding?

The authors have cherry picked results throughout this section. For example, they have selected only a few quotes from IPCC and NCA describing extreme heat. The absolute single daily maximum temperature for a given year, for example, is a poor statistic for assessing statistical changes in extreme heat (it would be like comparing the tallest person in each country to try to calculate change in average height). A complete and comprehensive review of the underlying assessments and the data it cites clearly shows that extreme heat has been increasing in North America.

- The heading of section 6.3.1 is a bit misleading as this is partly driven by warmer winters and fewer cold days.

The "climate less prone to extremes" is a misleading statement. If minimum temperatures are increasing faster than maximum temperatures (which is an expectation of climate change based on basic physical principals), then the difference between warm and cold extremes on many timescales is expected to decrease. There are reasonable points to be made regarding observational deficiencies, regional variations in extreme events, and the potential benefits of reductions in extreme cold, rather than coming up with misleading statistics.

The conclusion "The rise in Tmin has been strongly related to the growing presence of manufactured surfaces around the weather stations over the last 100+ years (the so-called urban heat island effect; Section 3.3 and Spencer et al. 2025)." is only found in an author's self-citation of Spencer, et al, (2025) that does not appear in the references at the end of Chapter 6. Further, the trend of greater increases in Tmin relative to Tmax is documented and explained in Easterling, et al (1997).

<https://doi.org/10.1126/science.277.5324.364>; Thorne, et al (2016) <https://doi.org/10.1002/2015JD024584>. The trend cannot be attributed to UHI effects.

The NCA5 is cited here and elsewhere. However, the USGCRP website that hosts the NCA reports has been removed. Hence, there is no way to read and review the referenced findings. This DOE report is therefore arguing against something that no longer exists, and that may appear questionable.

I am not sure how one can conclude that the temperature extremes have decreased based on figure 6.3.4. If I understand correctly the Tmax-Tmin for each year was tabulated and a mean of this difference averaged over the 100+ years was subtracted from these values to get some thing like a anomaly. This anomaly seems to have moved from +3F to -3F over the course of q00 years and now trending upwards again. This suggests to me that there has been significant changes in the extremes over the years and the most recent trend is towards warmer highs?

- Figure 6.3.5 shows the number of days greater than or equal to 95F in 6-year periods. Why show this in 6-year periods? That seems like an unusual choice. Would this look different with 5, 10, or 15 year periods?
- "We measure "Heatwave Days" here as the count of all days in May-Sep each year that exceed the 90th percentile for that day and that lie within a period of at least six consecutive days."
- Why six consecutive days? Would this look different for 5 days, a week, 10 days? Six days seems like an unusual period to pick.
- The dependence on and subsequent choice of reference periods is worrying. Can multiple reference periods be shown to show the dependence?

The NCA5 heading is not a controversial statement, it simply says that things are changing, which they are by the author's own admissions and graphs. It does not suggest pervasive positive trends, as the authors suggest it does.

The NCA5 is suggesting that the western US is experiencing increase in extreme heat (page 57, para 4); it seems like figure 6.3.5 establishes the fact and not contradict. There was no claim of pervasive (all CONUS) increase in the report

- "The NCA5 directs readers to the website <https://www.globalchange.gov/indicators/heat-waves> (USGCRP 2023)"
- Broken link.

The definition of heat wave as consecutive 6 days seems to be a special case. The standard definition is exceedance of 85 or 90 percentile for 2 or more days. I can't check with NCA5 as it was taken down from the web

Figure 6.3.6 establishes that heatwaves as defined here have increased in the west and have shown increasing trend all over CONUS in the past 50 years. [27] shows the results for the last 60 years and there is little doubt that there is an increase over most of the CONUS, again the NCA5 report is off the web; figure 6.3.7 shows the heat waves are monotonically increasing from the 1960. Including the longer data is only interesting in the dust bowl 1930 camouflage the signal somewhat for the Midwest and central plains. The problem of taking averages over large regions (for example entire CONUS) is that it kills the peak signals and smooths out the emergent climate change indicators. Doing continental averages to look for extremes is really not very useful. Secondly, there is no particular reason to assume that the climate change signal (i.e. the number of heat waves) should showing up 100 years ago, as the CO2 in the atmosphere started to be of significance in the last 50 years.

- This reads as a very selective analysis.

The statistical techniques used in the 2019 paper are highly non-standard for evaluating precipitation statistics, and the 2024 results have not been peer reviewed. The results reported in the NCA and IPCC and the underlying studies have clearly demonstrated that extreme precipitation is increasing.

The relevance of the paragraph on 19th century and paleoclimatic rainfall events is unclear. If anything, the fact that such extremes have occurred in the past argues for more aggressive adaptation measures to ensure that damages won't be as high if they happen again (even notwithstanding potential changes in risk due to climate change). Note, however, that additional context is provided in the box that follows two pages later.

averaged over all stations in the region, none of these trend parameters is statistically significant'. This is again how one would be looking at statistics of extremes in precipitation. As we know, precipitation is highly heterogenous and location dependent. As observed there are trends even with the approaches chosen by the authors of this study compared to NCA5 and averaging that over and saying there is no trend seems disingenuous.

The choice of looking at (only) 5-day precipitation totals is questionable. Most rainfall events, including the most extreme and damaging precipitation events, are typically on a daily timescale.

same argument as above

again the issue here is that we are talking about events that are happening in a short-time and over a small region. Averaging over time and space and develop statistics is probably not appropriate when we are talking about events such as the recent flooding event in Texas. If you average that event over 30 days, it will seem unremarkable.

As noted in NCA5 and shown in the analysis presented in figure 6.4.4 there is a clear trend of increase in extreme precipitation in 12 of the 27 stations analyzed. Again averaging over the entire region is not the best method for picking extreme precipitation events that are local both in time and space.

- Is this section suggesting that climate change is causing the decrease in tornadoes?
- This is another place where it would be better to reference newer literature and NCA5 instead of relying on NCA4. What has changed since then?

Perhaps this is more germane to the sea level rise section, but nuisance (high tide) flooding due to sea level rise has been observed across much of the united states.

- Figure 6.7.1, is this the same indicator used in AR6?

- “In summary there is no evidence of increasing drought frequency or intensity in the U.S. or globally over recent decades.”
- This statement is not supported by the citations presented here. AR6 finds that there are trends in agricultural and ecological droughts and this section does not contradict that finding, so this general statement about there being no evidence of increasing drought frequency or intensity is misleading.
- AR6 SPM A.3.2 – “Human-induced climate change has contributed to increases in agricultural and ecological droughts in some regions due to increased land evapotranspiration (medium confidence).”
Footnote, “Agricultural and ecological drought (depending on the affected biome): a period with abnormal soil moisture deficit, which results from combined shortage of precipitation and excess evapotranspiration, and during the growing season impinges on crop production or ecosystem function in general (see Annex VII: Glossary). Observed changes in meteorological droughts (precipitation deficits) and hydrological droughts (streamflow deficits) are distinct from those in agricultural and ecological droughts and are addressed in the underlying AR6 material (Chapter 11).”
- “The IPCC has not provided an assessment of wildfires.”
- AR6 WGII SPM discusses wildfire, and WG1 SPM discusses fire weather.
- AR6 WGII SPM – B.1.1, B.1.4, Fig. SPM.2, Fig. SPM.3, B.5.2, B.6.2, C.2.3, C.4.2, D.4.2,
- AR6 WGI SPM – C.2.4

However, there is evidence that flash droughts, which last weeks have increased over the Northeast and Midwest [28]

More recent analysis indicate forest loss due to wildfire accelerating over the recent past[29]. In particular there has been an increase in extreme fire radiative power with a 2 fold increase from 2003 to 2023 (period of satellite data availability)[30][31]. However, that these fires are not out-of-sample and there is a fire deficit as shown in figure 6.8.2 should be acknowledged. But this doesn't alleviate the concern that wildfire is leading to lot of socio-economic concerns and needs to be addressed[32]

The question of forest management and its role on wildfire frequency and intensity is interesting and deserves further study.

Patterns and variability of precipitation are poorly understood and models are particularly challenged to represent and predict precipitation, further research in this area is needed

The greater concern with hurricanes is the amount of moisture they carry and drop after landfall, i.e. flooding. While this is an active area of research, it is worth noting that this may be the bigger issue for hurricane change with warming

Combining heat and humidity as a measure of extreme heat is not unusual since it is this combination that is most impactful to human health - the body cannot cool if the humidity and heat are both high. Since a warmer atmosphere holds more moisture, and CO2 causes heat (and therefore moisture) to increase, this combination is a relevant assessment of the effects of CO2 on extreme conditions that make it difficult for people. Also combining with urban regions is helpful since that is where most people live. These points are not made in the report and are important.

The concern for many are the extreme hot temperatures without night-time cooling that provides an opportunity for recovery. This section doesn't address this. In this regards, the focus on the difference between extreme hot and extreme cold is misleading when generalizing about decrease in extremes (figure 6.3.4) - the decrease is because we don't have as much extreme cold.

Given the satellite observed ice sheet dynamics, I'm not sure that ice sheet retreat is that hypothetical.

- "The largest sea level increases along U.S. coasts are Galveston, New Orleans, and the Chesapeake Bay regions"

- How much? Are there quantifications?

The global mean sea-level was increasing at a rate of 0.08 inches/yr in 1993 compared 0.18 inches/yr in 2023, almost double the rate[33], which is approximately what is needed to meet the NOAA projections by mid-century and seems plausible.

This is the first time I have seen all sea-level rise estimates discredited by an offset from land subsidence. This is certainly a global dynamic that we would want to capture and understand in Earth system models, and DOE can look into this further with analyses and experiments if necessary.

The authors rightly describe the extreme uncertainty regarding sea level rise. It would be helpful to add some information about the complex, highly nonlinear and uncertain processes involved with ice-sheet dynamics and ice-sheet - ocean interactions that are especially key for Antarctica. **More research is needed to study and model ice sheet dynamics and ice-sheet ocean interactions.**

- "AR5 Working Group II (Cramer et al., 2014) makes the following statement:"

- What does AR6 say on this topic? The science on attribution has evolved since AR5.

- "There are three areas of substantive criticism of the IPCC's assessment of the causes of the recent warming..."

- Are there citations that can be included here or are these criticisms attributed to the authors?

- "IPCC's policy-informing..."

- This phrasing is a bit odd. IPCC reports are policy relevant but policy neutral. This phrasing the direct policy in some way.

"... datasets with high TSI variability can explain more than 70 percent of the temperature variability since preindustrial times." Variability on what time scales? 11-year cycles? How would this impact the well documented surface temperature increase of > 1 deg C global temperature change since 1900?

This and other chapters cite the IPCC AR6. The IPCC provides a global process to address the issues and uncertainties in this report. Perhaps this report can set a path for pivoting research and re-engaging in a useful manner.

A possible reason the method used by IPCC (optimal fingerprinting) can be considered to address McKittrick criticism is in [34]

- “For comparison, the IPCC estimate of forcing from the increase in atmospheric CO₂ compared to preindustrial times is approximately 2.2 W/m² (Figure 3.1.2).”
- This is comparing different time periods. Figure 8.2 includes data for 2023 and 2024, IPCC wouldn’t include the most recent years since it was published in 2021. Suggest updating from the IPCC data to Forster et al. (2024) that updates these indicators.
- Forster et al. (2024) “Indicators of Global Climate Change 2024: annual update of key indicators of the state of the climate system and human influence” <https://doi.org/10.5194/essd-17-2641-2025>
- “It is not easy to justify a new positive low cloud feedback that began emerging in 2015.”
- Explain why this is not easy?

The role of clouds remains the single most uncertainty in climate modeling, I am glad this was acknowledged here.

- “Other columns of IPCC Table 12.12 report on whether anthropogenic signals are expected to emerge this century under RCP8.5, the most extreme forcing scenario. We have omitted these columns for several reasons.”
- Can this be done for RCPs other than 8.5? The point of these omitted columns in IPCC Table 12.12 was to show that for some extremes we may not see an effect now, but will in the future. As it is presented here it implies future changes won’t matter.

The substance of this paragraph was addressed in my comments in earlier sections. Some of the claims made here are either exaggerations of the usual practice (RCP8.5 being referred to as BAU) or the comment about not fit for purpose (a comment extracted from a publication that is calling out for cloud resolved models.

What are the numbers in the 3rd column? Please include in the caption.

The discussion neglects the influence of vertical mixing on surface temperature. The global ocean has warmed, as documented by increases in global ocean heat content, e.g. Murphy, et al (2009)
doi:10.1029/2009JD012105

This section is hardly a balanced and objective review. The report authors are known opponents of optimal fingerprint approaches and have been a loud, but very small minority voice. It is interesting that even they conclude "...these analyses do not falsify results of the IPCC optimal fingerprinting method..."

This discussion is incomplete and fails to take into account the extensive literature on cloud and surface albedo feedbacks.. There is an extensive discussion about the post 2015 period and recent record annual global surface temperatures, implying, but not stating, that recent changes are the result of natural variability, or decreases in atmospheric aerosol concentrations. Comparing the radiative forcing from these changes with long-term GHG forcing, particularly CO₂ is misleading to the average reader. If the reduction in albedo can be tied to atmospheric cloud and aerosol changes, as the authors state, they cannot ignore the likelihood that the changes are the result of anthropogenic factors, i.e. sulfate aerosol reduction through cleaner technology and the well-documented positive low-cloud feedback.

Further research is needed on climate variability, effects of ocean circulation, solar variability, model simulation of variability and statistical methods.

Anthropogenic aerosol effects may also influence the inflections in temperature in ways that are challenging to account for

Reductions in aerosol indirect (cloud brightening) effects may also explain the reduced planetary albedo, not just from ships but from reduced fossil fuel aerosols coming from the continents, China and east asia especially. This paper describes the reduction in aerosols <https://www.nature.com/articles/s41612-023-00488-y> **This is another area that needs further research!**

I don't see an inconsistency between what Ch 11 and Ch 8 say. The first is about precipitation, droughts, tropical cyclones, heat - overall. The 2nd (ch 8) is about specific types of events in specific regions. Suggest to soften the statement about the contrasting assertions.

The science of attribution of extreme events is challenging and computationally expensive; this is an area where further research is needed with potential to use AI to improve statistics

- IPCC AR6 WGII has an assessment of agriculture (both in the SPM and in Chapter 5), and the IPCC also has a special report on Climate Change and Land, that are more comprehensive, recent, and cover a larger range of the literature than discussed here. Please update this chapter to reflect these findings.

This chapter is silent on agricultural effects on atmosphere and climate. Sokal and Kachel 2025 (10.3390/en18092272) conclude: "The current study demonstrated that agricultural activities significantly contribute to the emissions of three main greenhouse gases: carbon dioxide, nitrous oxide, and methane."

The last sentence in this summary is not necessarily accurate. The authors cite Ainsworth and Long (2020) with respect to increased CO2 effects on crops. But, Ainsworth and Long (2020) indicate that increased temp and decreased precipitation will have negative impacts on crops, while increased CO2 may offset some of those negative effects. It is the impact of CO2 on climate and the subsequent impact on crops that is the concern; not the direct effect of CO2 on crops.

The section title is "Field studies..." but the next three paragraphs are primarily about responses of potted plants in growth chambers or greenhouses (with exception of Blandino, which was a field study and showed a much smaller response than the pot studies). There is an important reason that the field data cited in Blandino and in SoyFACE show a smaller response than data from the potted plants under artificial conditions. These data are barely relevant to the topic you are trying to address.

CO2Science.org website is a highly biased and unreliable website. They report on papers, or specific sentences in papers, that support their view and ignore conflicting reports or qualifying sentences. This is a report for the US. Why are you citing soybean studies in China when there is a major soyFACE study in Illinois? Yield in SoyFACE increased in eCO2 but declined with increasing temperature (10.1093/jxb/erac503). eCO2 did not result in water savings as hypothesized but rather increased soil moisture depletion. (10.1098/rstb.2024.0230)

The problem with both the FACE studies and the soybean, Maize and wheat studies cited here are that they don't consider the effect of increase in temperature, changes in precipitation, humidity and other environmental factors along with CO2 increases. These compound effects have been shown in wide number of studies [35] [36][37][38][39]. A meta analysis of the compound effects shows that increase in CO2, along with temperature, precipitation changes effects the quality of the cereal and yields[40]. Another recent study evaluated the impacts on C3 and C4 crops and conclude that CO2 enrichment for C3 crops could increase but will be compensated by temperature increase. CO2 fertilization effect was found to be small for C4 [41]. It is important therefore that we consider the compound effects on crop yields and not just focus on CO2 enrichment.

Ainsworth et al, 2025 (10.1093/jxb/erac503) state: "Early season stimulation in biomass at elevated [CO2] more than offset lower stomatal conductance in crops, resulting in greater depletion of soil moisture, instead of water savings [30,31]. Wheat tiller survival and grain filling was also reduced by elevated [CO2] under dry conditions [32]. The CO2 fertilization effect was also significantly reduced by growth at elevated temperatures in FACE experiments, again suggesting that high atmospheric [CO2] may not offset the negative impacts of global warming [29]. Thus, it may be that, to date, elevated [CO2] and the resultant climate changes have had net positive effects on agroecosystem productivity, but as climate change intensifies, there will be a shift towards net negative effects as has been suggested for natural ecosystems [3]."

Taylor and Schlenker 2021 also note that 'Climate change will likely have negative impact on agriculture in aggregate, especially in regions exposed to extreme heat. And the CO2-driven yield increases may be offset by effects on food nutrition and quality'. However, the results for US have been a net positive in the recent past but not true in the lower latitudes.

Another study that should be cited is Hultgren et al, 2025 (10.1038/s41586-025-09085-w). "For all crops except rice, we estimate that warming will likely reduce global yields by 2050 (probability of loss ranges from 0.701 (sorghum) to 0.946 (wheat)..." "We estimate that global production declines 5.5×10^{14} kcal annually per 1 °C global mean surface temperature (GMST) rise (120 kcal per person per day or 4.4% of recommended consumption per 1 °C; $P < 0.001$). We project that adaptation and income growth alleviate 23% of global losses in 2050 and 34% at the end of the century (6% and 12%, respectively; moderate-emissions scenario), but substantial residual losses remain for all staples except rice." Regions with moderate average temperatures tend to suffer the largest yield losses.

"Adjusting for CO₂ fertilization does not qualitatively alter the structure of our findings ... but it does reduce the central estimate for end-of-century yield losses by 5.0– 9.5 percentage points... and increases the likelihood of positive aggregate effects."

Reference to Ziska paper greatly mischaracterizes it. Ziska clearly indicates an effect of eCO₂ on nutritional quality, but he indicates there is uncertainty in some of the mechanisms behind that response, including the simple dilution hypothesis. He states up front: "However, it is the direct effect of rising [CO₂] on plant chemistry and stoichiometry that represents a continuing threat to the nutritional integrity of both human and animal systems."

Evidence for nutritional decline under eCO₂ is widespread: Toreti et al, 2020 10.1038/s43016-020-00195-4) "A meta-analysis of 228 pairs of experimental observations on barley, potato, rice and wheat reported reductions in protein concentrations ranging on average from –15.3% to –9.8% under eCO₂, while the reduction was relatively small (–1.4%) in soybean." AND Ainsworth et al 2025: "The positive 'CO₂ fertilization' effect on crop yield is complicated by a decrease in many nutrients in elevated [CO₂]. An analysis of 130 varieties of plants found that elevated [CO₂] decreased the concentration of 25 important minerals by 8% on average, and the carbohydrate to mineral ratio was increased in these plants."

URL for Taylor and Schlenker paper is incorrect. It should be <https://www.nber.org/papers/w29320>. "papers" not "paper. Was this report peer reviewed? I cannot find it in a peer-reviewed journal.

This section seems to gloss over many key points. Certainly there are limits where extreme heat and drought (water is key) could be detrimental to crops. It also depends on which crops. There is extensive literature on how certain crop viability is shifting. So a region with particular crop experience and cultivation may no longer be able to sustain that agriculture. There is cost to shifting crops across regions and farmers that needs to be accounted for. And water is key - is there enough water in various regions for energy (power plants need water) as well as agriculture when conditions are very hot for sustained periods?

- Section 10.1 rightly points out that technological advances have substantially reduced losses from extreme weather events. We are better at forecasting, preparing for, and adapting to extreme weather than we were in the past, and these advances all help reduce impacts. However, our ability to do this in the future depends upon preparing for future changes – we can't simply assume adaptation will continue, we need to provide information on future risks and how those risks are impacted by climate change in order to inform continued technological advances and future adaptation.

- "In May 2025 NOAA announced it has withdrawn the Billion Dollar Disaster product from publication (Pielke Jr., 2025)."

- It would be better to cite an official government source from NOAA announcing this withdraw instead of a blog post commenting on it.

- Losses from extreme weather and climate events are driven by climate risk (the physical events themselves), exposure to those risks (population and infrastructure impacted by these events), and adaptation to those events (technological advances in forecasting, warning systems, and resiliency). Understanding these risks requires disentangling these drivers in order to prepare for the future.

The criticism of NOAA Billion dollar map is likely warranted as it was never completely transparent how the data was generated. However, changing the baseline assumption and refactoring the data using a different set of criteria to make the effects smaller also doesn't make sense. We should continue collecting this data and make the data accessible for researchers and peer review. Figure 10.1 doesn't address these issues, it is another methodology with unknown province of the data.

- There are additional citations that focus on the net effects of heat and cold related mortality that would be worth discussing and citing in this section.

- EPA. 2024. Draft Technical Documentation for the Framework for Evaluating Damages and Impacts (FrEDI). U.S. Environmental Protection Agency, EPA 430-R-24-001.

- Cromar et al., 2022. Global Health Impacts for Economic Models of Climate Change: A Systematic Review and Meta-Analysis. *Ann. Am. Thorac. Soc.* 19, 1203–1212. <https://doi.org/10.1513/AnnalsATS.202110-1193OC>

- Hsiang et al., 2017. Estimating economic damage from climate change in the United States. *Science* 356, 1362–1369.

- Mills et al., 2015. Climate change impacts on extreme temperature mortality in select metropolitan areas in the United States. *Clim. Change* 131, 83–95.

- Section 10.3.2 has good points about the importance of energy affordability and how energy poverty impacts adaptation behaviors. Cong et al. (2022) is another good citation for this section.

- Cong, S., Nock, D., Qiu, Y.L. et al. Unveiling hidden energy poverty using the energy equity gap. *Nat Commun* 13, 2456 (2022). <https://doi.org/10.1038/s41467-022-30146-5>

Severe weather continues to disproportionately impact lower income communities as well as business that requires outdoor exposure. A thorough analysis would need to include these points and I recommend adding this caveat to the section.

An additional concern is if the grid fails under either extreme heat demands or cold/severe-storm events, the impact on communities will not be uniform and depends on grid infrastructure which can be better in more affluent communities

Related to my previous comment, deaths due to extreme heat conditions appear to be increasing, particularly for certain populations and for those with underlying health conditions (which can be hard to detangle when attributing mortality). For example

<https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2792389>

- “Economists have long considered climate a relatively unimportant factor in economic growth, a view echoed by the IPCC itself in AR5.”

- It would be good to update this to the relevant conclusions in AR6 to reflect the more recent literature.

- This section makes an important point, much of the public does not understand that climate impacts are relative to projected future without climate change and need to be put in the context of economic growth and a future where our decedents are better off than we are today. O'Neill (2023) is a useful citation here, finding that, "Climate change research and assessments, including the most recent IPCC report, paint an increasingly dire picture of the future. However, the assumption that the future will be worse than the present may be wrong for many aspects of human well-being."

- O'Neill, B.C. Envisioning a future with climate change. *Nat. Clim. Chang.* 13, 874–876 (2023).

<https://doi.org/10.1038/s41558-023-01784-4>

Climate change can be expected to increase cold weather extremes in regions that have not been exposed to these effect

The same Nobel prize winning model in its most recent study concludes that [42] "We conclude with three results relevant for climate policy. First, both current policies (base run) and the extended Paris Accord fall short of limiting global warming to 2 °C or to the cost–benefit optimal level. Second, the economic stakes in global climate policy are substantial, with estimated net present value of economic benefits around \$120 trillion from the cost–benefit optimal policy. Third, once differences in discounting are considered, the baseline DICE-2023 estimate of the social cost of carbon (\$66/tCO₂ for 2020) aligns closely with other recent estimates". Obviously this is the latest and the current version of the model and these results are quite different from thus discussed on this page. These conclusions should also be included in this discussion to avoid selective reading of the literature.

- "Overall they could not detect a temperature effect on GDP or GDP growth, and they estimated the 95 percent confidence interval for the impact on global growth as of 2100 even under the exaggerated RCP8.5 warming scenario spans .86 percent to +388 percent. In other words the net effect is likely positive but too uncertain to distinguish from zero."

- This finding from Newell et al. (2021) needs to be contextualized with their complementary finding that models excluding growth effects and relating temperatures to GDP levels are far more certain. This is important to include since the actual USG application of SC-GHG does not include growth effects.

- Newell et al. (20201) states, "Models relating temperature to GDP levels yield climate impact estimates that are far more certain. The best such models imply GDP losses by 2100 of 1–3%, consistent with damage functions currently embedded in the major integrated assessment models that underpin the U.S. social cost of carbon."

- "To summarize, economists consider climate a relatively unimportant factor in economic growth, a view echoed by the IPCC itself in the Fifth Assessment Report."

- Need to update to reflect AR6 findings.

Similar empirical studies [43] point to "Using an empirical approach that provides a robust lower bound on the persistence of impacts on economic growth, we find that the world economy is committed to an income reduction of 19% within the next 26 years independent of future emission choices (relative to a baseline without climate impacts, likely range of 11–29% accounting for physical climate and empirical uncertainty). These damages already outweigh the mitigation costs required to limit global warming to 2 °C by sixfold over this near-term time frame and thereafter diverge strongly dependent on emission choices. Committed damages arise predominantly through changes in average temperature, but accounting for further climatic components raises estimates by approximately 50% and leads to stronger regional heterogeneity. Committed losses are projected for all regions except those at very high latitudes, at which reductions in temperature variability bring benefits. The largest losses are committed at lower latitudes in regions with lower cumulative historical emissions and lower present-day income". This study uses more of the daily temperature precipitation from 1600 hundred locations world wide instead of global means. There are numerous studies that show the cost, many described in the COP 21 and follow-on meetings

- "The concepts of estimation and uncertainty do not readily apply to SCC calculations."
- The discussion of uncertainty in IAMs should reflect EPA (2023) which incorporated many major advances in the treatment of uncertainty in integrated assessment modeling. See section A.8 of EPA (2023) for a summary of the quantified sources of uncertainty in the SCGHG estimates presented in EPA (2023)
- EPA (2023) "Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, 'Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review' – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances." Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf
- "Economists use IAMs to compute the SCC. Two of the best known are the Climate Framework for Uncertainty, Negotiation and Distribution ("FUND", Tol 1997) and Nordhaus' DICE."
- This is old literature. Given the advances since FUND and DICE were the leading SCC models, and this report's focus on literature post-2020, this section should be updated to focus on the models used to calculate the SC-GHG in EPA (2023) which represents advances over the approach used in FUND and DICE in response to NAS (2017) recommendations.
- EPA (2023) "Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, 'Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review' – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances." Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf

- “and a ‘judgmental adjustment’ of 0.5 percent for excluded impacts at 3°C warming”
 - EPA (2023) is the most up to date representation of the USG approach to SC-GHG incorporating the recommendations of the NAS (2017), and EPA (2023) explicitly does not included an adder for missing damages. This is another example of this chapter focusing on older less relevant literature, and it really should be comprehensively updated to address EPA (2023).
 - EPA (2023), page 59 states, “the model runs performed for this report do not adopt a 25% adder (as used in the DICE model (e.g., Nordhaus 2017)) to account for unknown or missing damages for the meta-analysis-based damage module.”
 - EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317.
 - NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” <https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of>
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- “Abatement costs: IAMs represent the cost to the economy of reducing CO2 emissions. If CO2 emission reductions are assumed to be inexpensive, then the model will conclude that the optimal policy should aim for deeper emission cuts and vice versa.”
 - IAMs such as DICE are often used in a mode of calculating the optimal level of abatement where they do indeed compare the SCC with the marginal cost of abatement to find the optimum. However, these abatement costs are not part of the SCC calculation, and as used by the USG for the purpose of regulatory impact analyses, this feature of these IAMs is not used. Instead the USG has other more appropriate tools for analyzing the costs of specific regulations. This distinction is important here as the assumptions about the cost of emissions abatement does not have any bearing on the calculation of the SCC.

- “For example, in 2023 the U.S. Environmental Protection Agency raised its preferred SCC value about 5-fold over the estimates it had issued ten years earlier. This is not because new data had been collected or better mathematical methods had been invented, but because new assumptions had been used, and the validity of those assumptions was a separate question.”
- This paragraph contains the only reference to EPA (2023). First, the characterization of this update as only because new assumptions are used is factually incorrect. EPA (2023) represents a significant change to how the USG calculated the SC-GHG moving away from the FUND/DICE/PAGE models used in the IWG era (see EPA (2016)) to a modular approach as recommended by NAS (2017). This chapter needs to address the NAS (2017) recommendations and the EPA (2023) response to those recommendations to capture how SC-GHG was actually used by the USG and how the literature has evolved over time.
- EPA (2016) “Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866 - Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf
- EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf
- NAS (2017) “Valuing Climate Damages. Updating Estimation of the Social Cost of Carbon Dioxide” <https://nap.nationalacademies.org/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of>
- “It should also be noted that the SCC is focused on the social costs of CO2 emissions from fossil fuel use. It does not measure the private marginal benefits to consumers and society from the availability of fossil fuels. Public willingness to pay for fuels of all types indicates the value to society of reliable, abundant fossil energy.”
- Two points to make about this section. First, the benefits to society generally accrue from the provision of energy services, not from specific fuels.” Second, the private marginal benefit of the availability of fossil fuels or energy services is not part of the SCC because changes in the cost and provision of the energy services should be part of the other side of the cost benefit analysis. The SCC is used to characterize the benefits of GHG emissions abatement, and the changes in the costs and availability of energy services are part of the cost of emissions abatement.
- “the uncertainty of SCC estimates doesn’t mean that other regulatory measures are inherently better or more efficient.”
- ‘regulatory measures’ is a poor word choice here as it can be confused with the regulation itself instead of the metric used to assess the regulation.

- This chapter has a heavy focus on the relation between climate change and economic growth and how this relationship factors into the SCC. There is an ongoing debate in the literature about persistence in climate damages as measured by changes in economic growth over time; however, these persistence effects on economic growth are not considered in the most recent version of the SC-GHG used by the USG – EPA (2023). This chapter generally ignores the existence of EPA (2023), it is mentioned once in passing, and does not inform readers that these controversial areas of current research are not included in government estimates of the SC-GHG.

- EPA (2023) page 58 says, “Given the statistical insignificance of the estimated coefficient on the productivity indicator in the published Howard and Sterner meta-analysis, the SC-GHG estimates presented in this report do not rely on Howard and Sterner’s specifications that include productivity effects. This is consistent with the authors’ recommendations in the published paper, to only consider the inclusion of the productivity impact in sensitivity analysis. However, the question of whether the effects of climate change impacts (e.g., temperature, tropical cyclones, and other extreme weather events) on the economy are only temporary or persistent is an active area of research. Over the past decade, a host of empirical studies have found evidence of temperature changes having persistent effects on the economy (e.g., Dell et al. 2012; Burke et al. 2015; Moore and Diaz 2015; Deryugina and Hsiang 2017; Ricke et al. 2018; Burke and Tanutama 2019; Colacito et al. 2019; Henseler and Schumacher 2019; Kahn et al. 2021; Kumar and Khanna 2019; Bastien-Olvera et al. 2022); this is an important finding because even small changes in economic growth rates accumulate into large economic impacts over time.”

- Section 11.2.4 has an interesting discussion of tipping points. This is an active area of research in the field, however it needs to be noted that tipping points or tipping elements are not included in the SC-GHG as used by the USG, see EPA (2023).

- EPA (2023), page 3 says, “For example, the modeling in this report omits most of the consequences of changes in precipitation, damages from extreme weather events, the potential for nongradual damages from passing critical thresholds (e.g., tipping elements) in natural or socioeconomic systems, and nonclimate mediated effects of GHG emissions other than CO₂ fertilization (e.g., ocean acidification due to CO₂ emissions, tropospheric ozone formation due to CH₄ emissions). Importantly, this update does not yet reflect interaction effects and feedback effects within, and across, natural and human systems. For example, it does not explicitly reflect potential interactions among damage categories, such as those stemming from the interdependencies of energy, water, and land use. These interactions and feedbacks, and others, were highlighted by the National Academies as an important area of future research for longer-term enhancements in the SC-GHG estimation framework.”

USG has actually implemented SCC. This chapter would benefit from a more explicit focus on EPA (2023) as it represents the latest state of the literature on SCC, shows how the USG applies the SCC for regulatory impact analyses, shows how the USG updated the older IAG era SCC as represented in EPA (2016) in response to the recommendations in NAS (2017), shows how uncertainty is incorporated into SCC estimates, and discusses areas of the literature that are on the frontier, highly uncertain, and not ready to be incorporated into the official USG estimates.

- As currently written much of this chapter is focused on these highly uncertain areas of the literature that are not incorporated into USG SCC estimates (e.g. tipping points, and climate change impacts on economic growth). EPA (2023) discusses these issues and why they are not ready to be incorporated into the official estimates.
 - Furthermore, EPA (2023) estimates of the SC-GHG does incorporate climate benefits such as CO₂ fertilization and reductions in cold mortality discussed elsewhere in this report, and this should be noted and discussed.
 - Finally, this section ignores areas of real controversy in the calculation of SC-GHG as it is used by the USG – namely the question of global vs. domestic benefits and the treatment of discounting when valuing benefits to future generations. These controversial issues deserve far more attention in this report instead of spending so much space on issues on the fringe of the literature that are not even included in USG SC-GHG estimates.
 - EPA (2016) “Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866 - Interagency Working Group on Social Cost of Greenhouse Gases, United States Government.” https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf
 - EPA (2023) “Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, ‘Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review’ – EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.” Docket ID No. EPA-HQ-OAR-2021-0317. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf
- The impacts of sea level rise and coastal inundation on coastal communities and in low-lying countries should be addressed. This will have impacts particularly on certain countries/regions but also on world economics

Research is needed to better understand the likelihood and impacts of various tipping points, including changes to ocean circulation patterns, ice sheet acceleration, sea-ice loss, die-off of tropical forests, thawing of permafrost, etc.

- This chapter summary is misleading as it is describing change from today’s temperature rather than the effect on future temperatures.
- “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO₂ concentration and hence human influences on the climate.”
- If global emissions were to go to zero tomorrow, CO₂ concentrations would stabilize, and global temperature would be approximately constant. Net negative CO₂ would result in reductions of concentrations and temperatures. In other words, while reducing global CO₂ emissions to zero might not lead to near-term reductions in CO₂ concentrations from today’s levels, it would stop future increases in CO₂ concentrations.

- This section is focused on unilateral action, but needs to address questions related to collective action and individual actions by multiple parties when the benefits of abatement and the damages from emissions have extensive externalities.
 - Kotchen (2021) provides a theoretical perspective on the global vs. domestic SCC question and addresses questions related to how an individual country's decisions are impacted by the expected choices of other countries given that GHG emissions are globally mixed the benefits of GHG abatement are shared widely.
 - Kotchen (2021). Which Social Cost of Carbon? A Theoretical Perspective. Journal of the Association of Environmental and Resource Economists. <https://doi.org/10.1086/697241>
- “Since that rate has been averaging about 50 percent of emissions in recent decades, a reduction of global emissions by 50 percent would (at least temporarily) halt the rise in atmospheric CO₂.”
- This may be addressed in earlier chapters that this reviewer has not read yet, but the standard framing is that stabilizing CO₂ concentrations requires balancing emissions by sources and removals by sinks. Removals by sinks includes both natural sequestration and anthropogenic sequestration (e.g. afforestation if it can be done that increases the overall land sink removal, or direct air capture). It could be useful to clarify this here.
- “Lomborg (2016) estimated that full compliance with the Paris Accord would not stop warming, it would only prevent about 0.1C warming and delay hitting the baseline year 2100 temperature levels by about a decade.”
- Note that the Lomborg (2016) finding is related to, “the of impact of the total, global emission cuts implied by all the submitted INDCs,” this is different than ‘full compliance with the Paris Accord’ as the INDCs analyzed in the paper are only the first round of Intended Nationally Determined Contributions submitted ahead of COP-21, and the Paris Accord requires additional Nationally Determined Contributions every 5 years. Since Lomborg (2016) only analyzes these INDCs, and parties have submitted two rounds of NDCs since then, suggest changing the wording here to, “... full compliance with initial commitments submitted ahead of the Paris Accord.”

comment, then again broken into multiple parts for ease of reading. This is PART 1]

- Section 12.1 is titled, “The scale of the problem,” is framed around contrasting criteria air contaminants with CO2 emissions; however, there really are three separate issues that need to be disentangled: Stock vs. Flow.

- The challenge here is that abatement costs borne by people today benefit people in the future – temporal externalities.

- CO2 emissions are a stock pollutant, so impacts depend on the cumulative emissions to date, whereas traditional criteria are a flow pollutant and impacts depend on the emissions at that point in time. Emissions of a stock pollutant going to zero will not affect impacts at that point in time, as the stock remains unchanged, but will have large impacts in the future as the stock will cease to increase until emissions resume; whereas emissions of a flow pollutant going to zero will immediately eliminate impacts, but impacts will have no lasting effects on future impacts as they will immediately resume when emissions resume.

- The sentence at the end of the second paragraph of this section reads, “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate.” This is conflating the expectations of how stock and flow pollutants work – if global emissions were to stop tomorrow, the fact that there would be no meaningful reduction in global CO2 concentrations is simply the nature of how stock pollutants work, but there would be very large impacts on future temperatures since the stock would cease to increase.

- The stock nature of CO2 emissions is a real challenge for justifying CO2 emissions reductions, but it is centered on justifying the costs of abatement being born by people today in order to create a stream of benefits that grow over time and primarily accrue to future generations. This leads to questions important questions about how decision-makers should think about inter-generational discounting, and what costs should or should not be borne today for the benefit of future generations that will potentially be substantially better off.

- It’s worth noting that since CH4 emissions are relatively short lived, they behave much more like a flow pollutant than a stock pollutant. If CH4 emissions went to zero, concentrations would fall relatively quickly,

- [NOTE: this comment is long and could be difficult to read in excel. It is included here once as a full comment, then again broken into multiple parts for ease of reading. This is PART 2]

Globally mixed.

- The challenge here is that abatement costs borne by people in one location benefit people in other locations – spatial externalities.

- The next issue is that GHG emissions are globally mixed, so that emissions in any one location have impacts all over the world. This is a distinct issue from the stock vs. flow issue, as the CH4 example above showed a flow pollutant can also be globally mixed. One can also consider a stock pollutant that is not globally mixed, such as groundwater pollution that depends on the stock of contaminants accumulating in the groundwater not just the flow in any one time period as one would see in surface water pollution.

- The globally mixed nature of GHG emissions is a real problem for justifying climate policy as the benefits of any one country’s actions primarily accrue to people in other countries. Conversely, a country benefits from the actions of every other country, not just their own actions. This is a problem of game theory and collective action, as unilateral action may not be justified even if collective action would be. It’s worth noting that this isn’t just a problem of scale – these same problems arise for globally mixed CH4 emissions even though as noted above they behave more as a flow pollutant, and would arise for any globally mixed pollutant regardless of the scale of the problem. There is an extensive literature on transboundary pollution that explores these issues.

comment, then again broken into multiple parts for ease of reading. This is PART 3]
Scale.

- The challenge here is that solving the problem requires enormous change and potentially enormous costs. However, individual actions need to be considered at the margin.

- As discussed in this section and the comments above, stabilizing CO2 concentrations and stopping the increase in global mean temperature requires balancing anthropogenic emissions and removals by sinks. The level global mean temperature stabilizes at would generally depend on the cumulative CO2 emissions up to the point CO2 emissions on net go to zero (the stock of CO2 emissions), and the level of short-lived non-CO2 emissions at that time (the flow of non-CO2 emissions). This would involve an enormous change to the global energy system. The costs of this change would be highly dependent on the timing of reaching net-zero CO2 emissions – in 10 years by 2035 would involve crippling costs to the global economy, in 100 years by 2125 would involve a far more gradual transition and likely impose minimal costs when discounted back to today.

- What is missing in this chapter is an acknowledgement that policy needs to be thought of at the margin. Do the marginal benefits of the policy equal or exceed the marginal costs? This is how economists think of these problems and the essence of how the government conducts cost-benefit analysis to inform decision-makers under E.O. 12866. The case study presented in section 12.2 poses the wrong two question. Showing that a policy's emissions reductions are small relative to global emissions, and the resulting impact on global temperatures is also small is tautological. No individual policy will solve climate change, but that does not mean that the individual policy is not justified. The relevant questions for decision makers are: (1) what is the cost of the marginal ton of emissions reductions by this policy? and (2) are those marginal costs smaller than the marginal benefit of a ton of emissions reductions? In practice, question (2) is very difficult to answer, and requires judgements about how to value benefits to Americans vs. benefits to the rest of the world, how to discount benefits that accrue to future generations, and how to consider the impacts U.S. actions have on the likelihood that other countries will take actions that benefit the U.S. These are difficult questions that need to be answered to justify climate policy, and this section would be improved by acknowledging that these are the questions that need to be addressed instead of the awkward argument

comment, then again broken into multiple parts for ease of reading. This is the full comment]

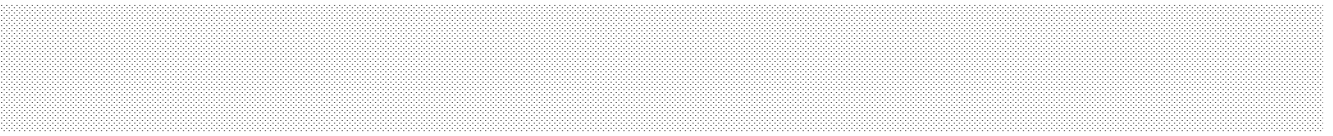
- Section 12.1 is titled, “The scale of the problem,” is framed around contrasting criteria air contaminants with CO2 emissions; however, there really are three separate issues that need to be disentangled:
 - Stock vs. Flow.
 - The challenge here is that abatement costs borne by people today benefit people in the future – temporal externalities.
 - CO2 emissions are a stock pollutant, so impacts depend on the cumulative emissions to date, whereas traditional criteria are a flow pollutant and impacts depend on the emissions at that point in time. Emissions of a stock pollutant going to zero will not affect impacts at that point in time, as the stock remains unchanged, but will have large impacts in the future as the stock will cease to increase until emissions resume; whereas emissions of a flow pollutant going to zero will immediately eliminate impacts, but impacts will have no lasting effects on future impacts as they will immediately resume when emissions resume.
 - The sentence at the end of the second paragraph of this section reads, “And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate.” This is conflating the expectations of how stock and flow pollutants work – if global emissions were to stop tomorrow, the fact that there would be no meaningful reduction in global CO2 concentrations is simply the nature of how stock pollutants work, but there would be very large impacts on future temperatures since the stock would cease to increase.
 - The stock nature of CO2 emissions is a real challenge for justifying CO2 emissions reductions, but it is centered on justifying the costs of abatement being born by people today in order to create a stream of benefits that grow over time and primarily accrue to future generations. This leads to questions important questions about how decision-makers should think about inter-generational discounting, and what costs should or should not be borne today for the benefit of future generations that will potentially be substantially better off.
 - It’s worth noting that since CH4 emissions are relatively short lived, they behave much more like a flow pollutant than a stock pollutant. If CH4 emissions went to zero, concentrations would fall relatively quickly,

The following sentence is misleading: "And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO2 concentration and hence human influences on the climate." It is true that bringing global emissions immediately to zero would not reduce CO2 concentrations on short timescales. It is not true that this same scenario means no reduction in human influence on the climate. We must compare the zero emissions scenario to something, and the most meaningful comparison is the current trajectory of **increasing** emissions and the resulting **super-linear** increase in concentration. So by reducing emissions to zero we clearly avoid the expected increases in concentration and the expected increases in radiative forcing together with increased near surface air temperature and all the other expected consequences. So our change in action - going to zero emissions - does in fact have an immediate and growing human influence on the trajectory of the climate system. That is not an argument for reducing our emissions to zero tomorrow, it is just an argument for logic and clarity in how we talk about consequences of different actions.

Regarding the sentence "The practice of referring to unilateral U.S. reductions as "combatting climate change" or "taking action on climate" therefore reflects a profound misunderstanding of the scale of the issue." This makes the dubious assumption that when people refer to "combatting climate change" or "taking action on climate" they are ignorant of the scale of the problem. Instead, it is probably more justifiable to assume that it is well-understood by most people who advocate for these local and national changes that the major emitters must act together to make a big difference in global emissions. It is at least worth considering, in the context of this report, that a path toward action at the necessary scale will require local and national action from a broad consortium, and that individual advocacy is a useful and necessary starting point for shifting the inertia of global policies.

This chapter is highly distressing, but I suppose it encapsulates the whole thesis of the document. Apparently, there is no point in policies to reduce emissions (or make the necessary changes in energy policy to accomplish emission reductions) because it will make no difference to the atmospheric CO₂ concentration or climate. So why bother? Would you have said this in 1970 (CO₂= 326), 1990 (CO₂ = 354 ppm), or 2010 (CO₂=390)? Probably so. And in 30 years when CO₂ is 500 ppm, will it be fair to look back and evaluate your apparent call for inaction in the statement here "And even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in the global CO₂ concentration and hence human influences on the climate." But I suppose this attitude is justified if there is no adverse consequence and the only important effect of rising CO₂ is to make little plants in greenhouse grow bigger (e.g., Fig. 2.3), and indirect effects on heat stress, drought, fires, sea level, etc. aren't worth discussing. While small in terms of global emissions (just from the US transport sector), over period this will be significant reduction. We need to remember that US is the second highest emitter of CO₂.

Do the authors think it worthwhile for private or public research, such as at DOE, to seek breakthrough technology that might effectively remove massive amounts of CO₂ from the atmosphere?



- [1] Rachel E. Mason et al. Evidence, causes, and consequences of declining nitrogen availability in terrestrial ecosystems. *Science* 376, eabh3767(2022).DOI:10.1126/science.abh3767
- [2] C.E. Moore, et al. The effect of increasing temperature on crop photosynthesis: from enzymes to ecosystems. *Exp. Bot.*, 72 (8) (2021), pp. 2822-2844

[3]C.R. Schwalm, S. Glendon,& P.B. Duffy, RCP8.5 tracks cumulative CO2 emissions, Proc. Natl. Acad. Sci. U.S.A. 117 (33) 19656-19657, <https://doi.org/10.1073/pnas.2007117117> (2020).
[4] C.R. Schwalm, S. Glendon, & P.B. Duffy, Reply to Hausfather and Peters: RCP8.5 is neither problematic nor misleading, Proc. Natl. Acad. Sci. U.S.A. 117 (45) 27793-27794, <https://doi.org/10.1073/pnas.2018008117> (2020).

[5] Sherwood, S. C., Webb, M. J., Annan, J. D., Armour, K. C., Forster, P. M., Hargreaves, J. C., et al. (2020). An assessment of Earth's climate sensitivity using multiple lines of evidence. *Reviews of Geophysics*, 58, e2019RG000678. <https://doi.org/10.1029/2019RG000678> [6]
Zelinka, M. D., Myers, T. A., McCoy, D. T., Po-Chedley, S., Caldwell, P. M., Ceppi, P., et al. (2020). Causes of higher climate sensitivity in CMIP6 models. *Geophysical Research Letters*, 47, e2019GL085782. <https://doi.org/10.1029/2019GL085782>

[7]Hausfather, Z., Drake, H. F., Abbott, T., & Schmidt, G. A. (2020). Evaluating the performance of past climate model projections. *Geophysical Research Letters*, 47, e2019GL085378. <https://doi.org/10.1029/2019GL085378>

[8] <https://www.cdc.gov/climate-health/php/effects/index.html>

[9] Xinyuan Wei et al 2025 Environ. Res. Lett. 20 064013

- [10]Liu, J., Wennberg, P.O. An emergent constraint on the thermal sensitivity of photosynthesis and greenness in the high latitude northern forests. *Sci Rep* 14, 6189 (2024). <https://doi.org/10.1038/s41598-024-56362-1>
- [11] Francesco S.R. Pausata, Marco Gaetani, Gabriele Missouri, Alexis Berg, Danielle Maia de Souza, Rowan F. Sage, Peter B. deMenocal, The Greening of the Sahara: Past Changes and Future Implications, *One Earth*, Volume 2, Issue 3, 2020, Pages 235-250, ISSN 2590-3322,<https://doi.org/10.1016/j.oneear.2020.03.002>.
- [12]Lesk, C., Anderson, W., Rigden, A. et al. Compound heat and moisture extreme impacts on global crop yields under climate change. *Nat Rev Earth Environ* 3, 872–889 (2022). <https://doi.org/10.1038/s43017-022-00368-8>

[13]Xin Chen, Tiexi Chen, Bin He, Shuci Liu, Shengjie Zhou, Tingting Shi, The global greening continues despite increased drought stress since 2000, Global Ecology and Conservation, Volume 49, 2024, e02791,ISSN 2351-9894,

[14] Ursula M. Ruiz-Vera, Matthew Siebers, Sharon B. Gray, David W. Drag, David M. Rosenthal, Bruce A. Kimball, Donald R. Ort, Carl J. Bernacchi, Global Warming Can Negate the Expected CO₂ Stimulation in Photosynthesis and Productivity for Soybean Grown in the Midwestern United States , *Plant Physiology*, Volume 162, Issue 1, May 2013, Pages 410–423, <https://doi.org/10.1104/pp.112.211938> [15] Lamba S, Hall M, Råntfors M, et al. Physiological acclimation dampens initial effects of elevated temperature and atmospheric CO₂ concentration in mature boreal Norway spruce. *Plant Cell Environ.* 2018; 41: 300–313. <https://doi.org/10.1111/pce.13079>

- [16]van Vuuren, D.P., Edmonds, J., Kainuma, M. et al. The representative concentration pathways: an overview. *Climatic Change* 109, 5 (2011). <https://doi.org/10.1007/s10584-011-0148-z>
- [17]Hausfather, Z. (2025). An assessment of current policy scenarios over the 21st century and the reduced plausibility of high-emissions pathways. *Dialogues on Climate Change*, 2(1), 26-32. <https://doi.org/10.1177/29768659241304854> (Original work published 2025)

- [18] Parker, D. Large-scale warming is not urban. *Nature* 432, 290 (2004).
<https://doi.org/10.1038/432290a>
- [19] Parker, D.E. (2010), Urban heat island effects on estimates of observed climate change. *WIREs Clim Change*, 1: 123-133. <https://doi.org/10.1002/wcc.21>.
- [20] Parker, D. E., 2006: A Demonstration That Large-Scale Warming Is Not Urban. *J. Climate*, 19, 2882–2895, <https://doi.org/10.1175/JCLI3730.1>.

[21] Michael Mann, Our Fragile Moment: How lessons from Earth's past can help us survive climate crisis, Hach

[22]Hausfather, Z., Drake, H. F., Abbott, T., & Schmidt, G. A. (2020). Evaluating the performance of past climate model projections. *Geophysical Research Letters*, 47, e2019GL085378. <https://doi.org/10.1029/2019GL085378>

[23]Chung, ES., Kim, SJ., Sohn, BJ. et al. Multi-decadal climate variability and satellite biases have amplified model-observation discrepancies in tropical troposphere warming estimates. *Commun Earth Environ* 5, 342 (2024). <https://doi.org/10.1038/s43247-024-01510-8>

[24]Merlis, T. M., Guendelman, I., Cheng, K.-Y., Harris, L., Chen, Y.-T., Bretherton, C. S., et al. (2024). The vertical structure of tropical temperature change in global storm-resolving model simulations of climate change. *Geophysical Research Letters*, 51, e2024GL111549. <https://doi.org/10.1029/2024GL111549>

[25] B.D. Santer, S. Po-Chedley, L. Zhao, C. Zou, Q. Fu, S. Solomon, D.W.J. Thompson, C. Mears, & K.E. Taylor, Exceptional stratospheric contribution to human fingerprints on atmospheric temperature, *Proc. Natl. Acad. Sci. U.S.A.* 120 (20) e2300758120, <https://doi.org/10.1073/pnas.2300758120> (2023).

[26]Cohn, T. A., and H. F. Lins (2005), Nature's style: Naturally trendy, Geophysics. Res. Lett., 32, L23402, doi:10.1029/2005GL024476.

[27]<https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves>

[28]Ronald D. Leeper, Rocky Bilotta, Bryan Petersen, Crystal J. Stiles, Richard Heim, Brian Fuchs, Olivier P. Prat, Michael Palecki, Steve Ansari

[29]Tyukavina Alexandra , Potapov Peter , Hansen Matthew C. , Pickens Amy H. , Stehman Stephen V. , Turubanova Svetlana , Parker Diana , Zalles Viviana , Lima André , Kommareddy Indrani , Song Xiao-Peng , Wang Lei , Harris Nancy; Global Trends of Forest Loss Due to Fire From 2001 to 2019, *Frontiers in Remote Sensing*.Volume 3 – 2022,2022.

[30]Cunningham, C.X., Williamson, G.J. & Bowman, D.M.J.S. Increasing frequency and intensity of the most extreme wildfires on Earth. *Nat Ecol Evol* 8, 1420–1425 (2024).

<https://doi.org/10.1038/s41559-024-02452-2>

[31]Patrick H. Freeborn, W. Matt Jolly, Mark A. Cochrane, Gareth Roberts, Large wildfire driven increases in nighttime fire activity observed across CONUS from 2003–2020, *Remote Sensing of Environment*, Volume 268, 2022,12777

[32]Parks, S.A., Guiterman, C.H., Margolis, E.Q. et al. A fire deficit persists across diverse North American forests despite recent increases in area burned. *Nat Commun* 16, 1493 (2025).

<https://doi.org/10.1038/s41467-025-56333-8>

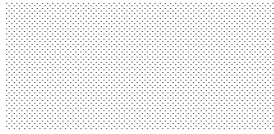
[33]Hamlington, B.D., Bellas-Manley, A., Willis, J.K. et al. The rate of global sea level rise doubled during the past three decades. *Commun Earth Environ* 5, 601 (2024). <https://doi.org/10.1038/s43247-024-01761-5>

[34]Chen, H., Chen, S.X. & Mu, M. A statistical review on the optimal fingerprinting approach in climate change studies. *Clim Dyn* 62, 1439–1446 (2024). <https://doi.org/10.1007/s00382-023-06975-5>

[35] Ruiz-Vera UM, Siebers M, Gray SB, Drag DW, Rosenthal DM, Kimball BA, Ort DR, Bernacchi CJ. Global warming can negate the expected CO₂ stimulation in photosynthesis and productivity for soybean grown in the Midwestern United States. *Plant Physiol.* 2013 May;162(1):410-23 [36] Levine LH, Richards JT, Wheeler RM. Super-elevated CO₂ interferes with stomatal response to ABA and night closure in soybean (*Glycine max*). *J Plant Physiol.* 2009 Jun 1;166(9):903-13. [37]Večeřová K, Oravec M, Puranik S, Findurová H, Veselá B, Opoku E, Ofori-Amanfo KK, Klem K, Urban O, Sahu PP. Single and interactive effects of variables associated with climate change on wheat metabolome. *Front Plant Sci.* 2022 Oct 10;13:1002561. [38]Thomas, J.M.G., Boote, K.J., Allen, L.H., Gallo-Meagher, M. and Davis, J.M. (2003), Elevated Temperature and Carbon Dioxide Effects on Soybean Seed Composition and Transcript Abundance. *Crop Sci.*, 43: 1548-1557. <https://doi.org/10.2135/cropsci2003.1548> [39] Lesk, C., Anderson, W., Rigden, A. et al. Compound heat and moisture extreme impacts on global crop yields under climate change. *Nat Rev Earth Environ* 3, 872–889 (2022). <https://doi.org/10.1038/s43017-022-00368-8> [40] Ben Mariem S, Soba D, Zhou B, Loladze I, Morales F, Aranjuelo I. Climate Change, Crop Yields, and Grain Quality of C3 Cereals: A Meta-Analysis of [CO₂], Temperature, and Drought Effects. *Plants.* 2021; 10(6):1052. <https://doi.org/10.3390/plants10061052> [41]Rezaei, E.E., Webber, H., Asseng, S. et al. Climate change impacts on crop yields. *Nat Rev Earth Environ* 4, 831–846 (2023). <https://doi.org/10.1038/s43017-023-00491-0>

[42]L. Barrage, & W. Nordhaus, Policies, projections, and the social cost of carbon: Results from the DICE-2023 model, Proc. Natl. Acad. Sci. U.S.A. 121 (13) e2312030121, <https://doi.org/10.1073/pnas.2312030121> (2024).

[43] Kotz, M., Levermann, A. & Wenz, L. The economic commitment of climate change. *Nature* 628, 551–557 (2024). <https://doi.org/10.1038/s41586-024-07219-0>



ette Group Inc., 2024.

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Thursday, July 31, 2025 5:16 PM
To: 'Judith Curry'; 'Roy Spencer'
Cc: 'Ross McKittrick'; 'John Christy'; 'Josh Loucks'; 'Cohen, Seth'; 'Fisher, Travis'
Subject: RE: DOE reviews
Attachments: ~WRD0003.jpg; image001.png

Are we intending to post the DOE reviews and responses? Seems like that would be a good idea. (Could keep the reviewers anonymous if that matters to them).

SEK

From: Judith Curry <curry.judith@gmail.com>
Sent: Thursday, July 31, 2025 5:06 PM
To: Roy Spencer <roywspencer@hotmail.com>
Cc: Ross McKittrick <ross.mckittrick@gmail.com>; John Christy <climateman60@gmail.com>; Steven Koonin <steven.koonin@googlemail.com>; Josh Loucks <loucksj14@gmail.com>; Cohen, Seth <seth.cohen@hq.doe.gov>; Fisher, Travis <travis.fisher@hq.doe.gov>
Subject: DOE reviews

Ross, if you can send me the latest version of the 8 DOE review responses, i can clean those up, verify changes were made, and send around for approval. Would be good to get those out of the way before the public comments

On Thu, Jul 31, 2025 at 12:27 PM Roy Spencer <roywspencer@hotmail.com> wrote:

Ironic that no one cared when MY work was mischaracterized by the 97-Percenter's as being part of the 3%, even though by their criteria I was part of the 97% consensus.

I complained, but all they said was, "well, we put you in the 3 percent category".

The bias is rampant.

-Roy

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Thursday, July 31, 2025 11:27 AM
To: Roy W. Spencer <roywspencer@hotmail.com>; Judith Curry <curry.judith@gmail.com>; John Christy <climateman60@gmail.com>; Steven Koonin <steven.koonin@googlemail.com>; Josh Loucks <loucksj14@gmail.com>; Cohen, Seth <seth.cohen@hq.doe.gov>; Fisher, Travis <travis.fisher@hq.doe.gov>
Subject: Fwd: Fw: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

John and I got this from Tim Vogelsang at MSU. Carbon Brief is contacting everyone whose work was cited trying to gather up claims of misrepresentation. As Tim notes, there is no option on the form for saying your work was correctly characterized.

From: Vogelsang, Timothy <tjv@msu.edu>
Sent: Thursday, July 31, 2025 12:19 PM
To: Ross McKittrick <rmckitri@uoguelph.ca>; John Christy <climateman60@gmail.com>
Subject: RE: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

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If you look at the pdf I was sent with the instructions, there is no option to report that someone's research has been correctly characterized. That's not a very scientific factchecking exercise, is it!

Tim

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I've heard of Carbon Brief but only read snippets of their articles cited elsewhere. They seem to be heavily into promoting renewables.

It's interesting to watch the machine swing into gear. There is a public comment docket opening up and I expect there will be quite the avalanche of material submitted, which we will need to prepare responses to, all of which will form part of the public record. If the comments are substantive we'll readily make revisions. We responded to a lot of comments from the internal DoE staff during the pre-publication review stage. But some of the most hostile comments didn't provide any data or citations in support so we couldn't do anything with them.

Ross

Dr. Ross McKittrick

Professor of Economics

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Ross and John,

I just got this email. Maybe you know about this group. I'm sure this is just the tip of the iceberg of pushback coming.

Tim

From: Leo Hickman <leo.hickman@carbonbrief.org>
Sent: Thursday, July 31, 2025 11:49 AM
To: Leo Hickman <leo.hickman@carbonbrief.org>
Subject: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

Hello,

I'm contacting you because we have noticed that at least one of your studies has been cited in a new report published this week by the US Dept of Energy titled, "A Critical Review of Impacts of Greenhouse Gas Emissions on the U.S. Climate."

A number of scientists cited in the report have already publicly highlighted that their findings have been falsely or misleadingly characterised. It seems that the report is intended to be used as scientific justification by the Trump administration in its efforts to revoke the US Environmental Protection Agency's "endangerment finding" on greenhouse gases.

Carbon Brief is now seeking your help to assess whether your own study, or indeed your area(s) of expertise more widely, have been mischaracterised in the report. This is part of a wider 'crowdsourced' fact-checking effort we are now convening to draw on inputs from experts in their respective fields.

I have attached a PDF with some instructions on how you can participate with your own insights and reflections, should you wish. (The instructions include ways to do this anonymously and securely, if that is your preference.)

Additionally, if you know of a colleague or co-author who might wish to participate, please feel free to forward this email to them.

Our deadline for submissions is Monday 11 August 2025 - 0900 GMT.

Many thanks in advance.

Best wishes, Leo

--

Leo Hickman

Editor, Carbon Brief

Phone: + 44 (0) 7731 403979

Social: Twitter; BlueSky: LinkedIn

Web: www.carbonbrief.org

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Judith Curry, President
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To: Roy Spencer [roywspencer@hotmail.com]
CC: Ross McKittrick [ross.mckittrick@gmail.com]; John Christy [climateman60@gmail.com]; Steven Koonin [steven.koonin@googlemail.com]; Josh Loucks [loucksj14@gmail.com]; Cohen, Seth [seth.cohen@hq.doe.gov]; Fisher, Travis [travis.fisher@hq.doe.gov]
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Sent: Thursday, July 31, 2025 11:49 AM
To: Leo Hickman <leo.hickman@carbonbrief.org>
Subject: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

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Many thanks in advance.

Best wishes, Leo

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Leo Hickman

Editor, Carbon Brief

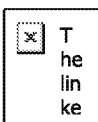
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Network
Reno, NV USA
curry.judith@cfanclimate.com |
+1.404.803.2012

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Saturday, August 2, 2025 7:07 AM
To: Judith Curry
Cc: Travis Fisher; Ross McKittrick; Roy Spencer; Charles Park; John Christy; Joshua Loucks; Seth Cohen; Audrey Barrios
Subject: Re: Comment portal

Link to the comment portal now included on the DOE climate page.

<https://www.federalregister.gov/documents/2025/08/01/2025-14519/notice-of-availability-a-critical-review-of-impacts-of-greenhouse-gas-emissions-on-the-us-climate>

Steven E. Koonin

On Aug 1, 2025, at 16:42, Judith Curry <curry.judith@gmail.com> wrote:

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Best,

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Phone conference ID: 530 567 526#

For organizers: [Meeting options](#) | [Reset dial-in PIN](#)

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Subject: Re: [EXTERNAL] DOE reviews

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John and I got this from Tim Vogelsang at MSU. Carbon Brief is contacting everyone whose work was cited trying to gather up claims of misrepresentation. As Tim notes, there is no option on the form for saying your work was correctly characterized.

From: Vogelsang, Timothy <tjv@msu.edu>

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Ross

Dr. Ross McKittrick

Professor of Economics

Department of Economics and Finance

rossmckittrick.com

<image001.png>

University of Guelph | Guelph ON Canada N1G 3P9

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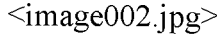
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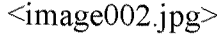
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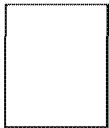
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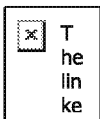
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I wonder what the corresponding stats would be for NCA5 or AR6 WG1.

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In case allegations of a "minority" viewpoint come up, this might help offset that:

In our report, there are:

350 references, of which
23 have us as lead- or co-authors

So, only **6.6%** of the reference mentions in the report come from OUR research. (Those are the total reference mentions, including double- or triple-counting).

By the way, Ross wins by a large margin, and John gets an Honorable Mention.

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